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SPECIALIZED FOR EXPLORATION, DRILLING, PRODUCING OPERATIONS AND MANAGEMENT

Gulf Publishing Company

EXPLORATION PROGRESS ISSUE

Latest advancements and trends in the exploration

Pages 116-151

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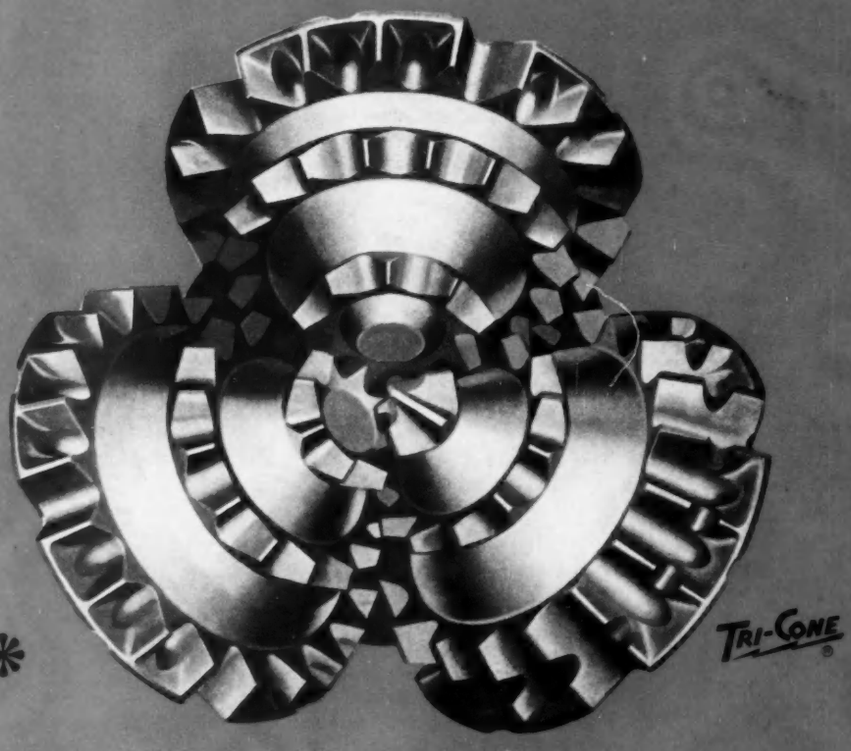

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Volume 146, No. 5 April, 1958

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WORLD OIL

Established 1916 as The OIL WEEKLY®

a quick look at this issue

BUSY OIL MEN: To help you put first things first, scan these time-saving digests on this and the following pages, checking ☑ those you want to read first.

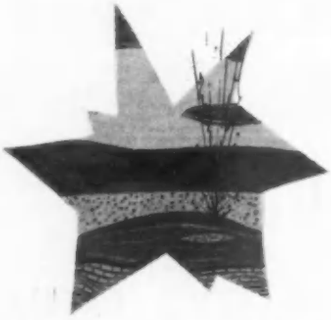
CURRENT OUTLOOK

☐ **If activity during the last half of 1957 is any measure,** the Williston Basin on both sides of the North Dakota-Montana border is headed for new discovery records. Last year, North Dakota set a new record of 23 discoveries, with a wildcat success ratio of nearly 15 percent. Some 30 to 40 rigs were active in Montana during the latter part of 1957. For a detailed report on these "hot oil areas", including prospects for new discoveries. **New Discoveries Boost Williston Basin Activity** ... **Page 94**

☐ **Oil industry earnings** will continue to compare unfavorably with those a year earlier for both the first and second quarters of this year. They may look better when third quarter statements come out next October and November. Following the profitable first and second quarters of 1957, earnings sagged in the third quarter and were off substantially in the fourth quarter. The gains made in the first half were largely canceled out by the decreases of the latter half. Thus 1957 earnings were about the same as those of 1956. **Earnings Due to Lag in 1958 After Last-Half 1957 Drop** ... **Page 97**

☐ **Proved reserves of crude and natural gas liquids** totaled 36 billion barrels at the end of 1957 —349 million barrels under the 1956 total. This was the first time operators failed to prove up more reserves than they produced since 1943. Five year comparisons show that the six top liquid hydrocarbon states are now accounting for a smaller portion of U.S. reserves, while four Rocky Mountain states are increasing their percent of the total. Turn to **Page 99. U.S. Liquid Hydrocarbon Supply Shows First Drop in 15 Years** ... **Don E. Lambert**

Turn the Page ▸



Exploration progress . . .

☐ **Past exploration records have set a high mark** tomorrow's activity. Oil aplenty exists but it must be found to meet requirements for the years ahead. An authority in the field sums it up with some editorial comments on **Page 117. . . . Graham B. Moody**

☐ **The use of magnetic tape** in recording seismic field data is being re-evaluated by some oil companies and geophysical contractors. In some areas, data have not improved sufficiently to justify its use. Elsewhere, data have been upgraded when tape was used. The status of standardization also is discussed in the article beginning on **Page 119. Let's Take a Second Look at Magnetic Tape. . . . . C. F. Wendenburg and John M. Sharpe**

☐ **Aerial color photography** is proving a helpful exploratory tool. Key beds can be traced over greater distances. Faster and more accurate correlation results. Cost-wise, color is still more expensive than black-and-white. But recent technological advances in film processing are narrowing the gap. Take a look at the possibilities on **Page 123. Color Aids Photogeological Interpretation. Dr. J. I. Gimlett and Kenneth E. Hunter**

☐ **A new frontier for seismic prospecting** is the Algerian Sahara desert. Some 20 seismic reflection and refraction crews (including two weight-dropping crews) and four gravity crews were operating there at the end of 1957. Problems are plentiful in the 280,000-square-mile area. See **Page 126. Algeria's Sahara: Booming Seismic Frontier. . . . . Alan D. Waldie**

☐ **Exploratory outlook is bright in Four Corners area.** Deeper possibilities, large unexplored structures and known reserves in the San Juan and Paradox basins, plus the added attraction of the relatively unexplored Black Mesa Basin are causing many operators

☐ **The natural gas industry marked up** another record year in 1957. Total reserves were increased 8.8 trillion cubic feet to a new high of 246.6 trillion cubic feet. Louisiana was the biggest contributor to the increase, accounting for 49 percent of the new discoveries and 73 percent of the gain in total U.S. reserves. For a complete report on the natural gas industry's activity last year. **Natural Gas Reserves Reach New High During 1957. . . . . Page 101**

☐ **Your acceptance of World Oil** has made it possible for the magazine to set new records in circulation and advertising since 1952. You, the subscriber, have been the key factor in our growth, so we want to share with you this outstanding example of our progress. **$1 Million Investment in the Future. . . . . Page 102**

☐ **Some relief** from current low producing levels for U. S. crude oil producers during the last half of 1958 now seems more likely. Drastic production cuts in March and April should go a long way toward eliminating excessive inventories of crude oil. Cold weather has absorbed all excessive stocks of distillate fuel oil and kerosene. Only gasoline and residual fuel oil stocks are excessive. Low refinery crude runs during next three months would permit higher gasoline and residual demand to these inventories into line. **Page 110. Brighter U. S. Oil Outlook Is in Sight. . . . . Warren L. Baker**

DRILLING ARTICLES

☐ A new grade of casing is now being manufactured which withstands the high pressures of deep drilling. A comparison of the design considerations of four different grades of strings shows the advantages of stronger casing. Increased yield strengths of this casing are discussed. Turn to **Page 153. High Strength Casing for Bottom-Hole Pressures of 15,000 PSI. . . . . Sheldon H. Reynolds**

☐ **The effect of pipe rotation** on fluid flow has been an almost neglected phase of drilling research. Here's an experiment that shows a net power saving results from the reduction of pressure drop at rotational speeds greater than 100 rpm. See **Page 158** for a complete explanation. **Drill Pipe Rotation Reduces Pressure Drop. Howard Ferrell, E. C. Fitch and J. H. Boggs**

☐ **Reclaiming useful mud can result in savings.** Where the drilling mud program has become standard and there is a concentration of activity, Gulf Oil Corporation has shown that barges equipped for mud salvage can effect savings of more than $800,000 in 18 months. For a description of the equipment used, see **Page 165. Mud Reclamation Is Found Successful D. M. Jeffus and V. T. Jones, Jr.**

☐ **A new thermal setting epoxy resin,** applied to casing joints like thread dope, provides greater

. . . 1958

to focus attention on this "hot spot." Turn to **Page 130. Geology and Exploration in the Four Corners Area**. . **Bert F. Gray, Jr.**

☐ **Deeper possibilities of the Paradox** were brought to light by the discovery of commercial production in the Mississippian at Big Flat in the Utah sector of the Paradox Basin. Turn to **Page 136** for information of high interest to exploration men and contractors. **Deeper Possibilities of the Paradox Studied**. . **Dr. Carl A. Moritz**

☐ **Two new radio-geophysical methods** have been developed that will successfully map conventional structures and stratigraphic traps. The methods are not dependent on mapping of structure but are based on the strength of the reflected or re-radiated hydrocarbon waves. See **Page 140. New Way to Locate Stratigraphic Traps**. . . . . **Donald W. Slattery**

resistance to breakout than tack welded joints. See **Page 168** for background problems and facts about make-up and application. **New Compound Developed for Locking Casing Joints**. . . . . **Martin E. True and W. A. Pitts**

☐ **A rundown of the latest money-saving use** of air circulating media and aerated drilling fluids begins on **Page 175. Shell Cuts Drilling Costs**. . . . . **T. W. G. Richardson**

☐ **Reduce the problem of checking spray patterns** of diesel injector nozzles by using fluorescent dyes and black light. Test sprays are more easily seen by the inspector with these aids. **Diesel Fuel Injection Patterns Checked Under Black Light**. . **Page 180**

☐ **An extreme pressure lubricant** added to any of the conventional drilling muds has extended bit bearing life from two to four times and reduced the required torque for pipe rotation. For information on field and laboratory tests, read. . . . . **Lubricating Mud Additive Extends Bit Life**. . . . . **Page 186**

PRODUCTION ARTICLES

☐ **An eight-year engineering committee study,** worked out on electronic data processing and computing machines, developed the basis for unitization of the major portion of the Seeligson field. Unitized operation of 58 reservoirs will increase ultimate recovery by 60 million barrels of oil. Details of the study and the complex nature of reservoir structures are presented on **Page 191. Seeligson Unit Formed for Secondary Recovery**. . . . . **John N. Schuelke**

☐ **An important experiment in oil recovery** is being tried by Sunray Mid-Continent Oil Company in two of its fields, with one field being the test for the double purpose of storage and recovery. Turn to **Page 201** for an explanation of methods used and returns expected. **New Repressuring Method Promises to Triple Output**. . . . . **Charles Schnake**

☐ **An important tool** in many areas for stimulating production is hydraulic fracturing. There is still considerable debate, however, on the geometric pattern of hydraulically induced fractures. See **Page 203** for a discussion of that portion of this picture dealing with stress analysis. **What Happens to Hydraulic Fractures H. Ode**

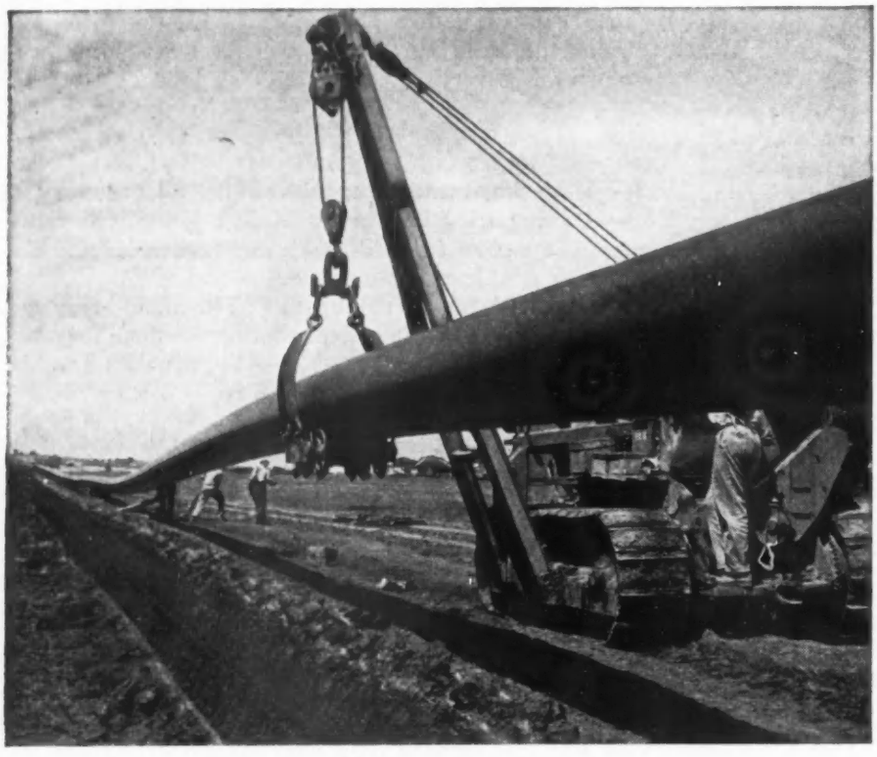
☐ **Here's a refresher on rules** for setting up a good safety program for transporting, erecting and operating production equipment in the field. Turn to **Page 208. Safe Production Practices Save Money**. . . . **Ben Adair**

☐ **A new model for porous medium** forms the basis for a discussion of tortuosity and formation factor. An explanation of the model and its application to some of the problems of fluid flow is given in the conclusion of this two-part series on **Page 210. The Generalized Kozeny-Carman Equation: Its Application to Problems of Multiphase Flow in Porous Media (Part 2)**. . . . . **M. R. J. Wyllie and G. H. F. Gardner**

INTERNATIONAL

☐ **Two new producing areas in the Sahara Desert** of Algeria show indications of being major fields. The Hassi R'Mel wet gas field is estimated to have proved reserve of 150 million barrels of liquid petroleum along with large gas reserves. It may eventually yield crude oil also. Hassi Messauoud oil field is conceded 800 million barrels of presently proved reserves. It is believed that further development may increase the reserves to billions of barrels. **Two Sahara Areas Confirmed as Major Fields**. . . . . **Page 233**

Canada uncorks its gas resources



For Canada's vast, almost untouched supply of natural gas, outlets have already been planned to deliver over 10 trillion cubic feet to North American markets. Canadian gas reserves are expected by 1970 to approach 55 trillion cubic feet.

To bring this fuel to millions of future consumers, the great Trans-Canada gas line is designed to span the 2250 miles from Alberta to Ontario. Westcoast Transmission lines will carry British Columbian gas to the U. S. Pacific Northwest. A network of complementary lines will blanket Western Canada's fields. All this at a cost close to $600 millions by 1959.

The Canadian Bank of Commerce maintains a complete Petroleum and Natural Gas Department in Calgary, and more than 270 branches throughout Western Canada. For information on any aspect of the industry in Canada, write or telegraph to C. H. Munro, Manager, Petroleum and Natural Gas Department, 309 Eighth Avenue, West, Calgary, Alberta.

(*We regret that we cannot advise on the merits of oil or mining securities.*)

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PETROLEUM REFINER and THE REFINERY CATALOG for the refining-natural gasoline-petrochemical industry.

PIPE LINE INDUSTRY and THE PIPE LINE COMPOSITE CATALOG for the oil and gas pipe line industry.

Indexed by Industrial Arts Index and Engineering Index

Looking Ahead . . .

Oil Allowables to Continue at Low Level . . . Excessive stocks, plus low seasonal demand, are still taking toll of production in major oil areas—**Predictions are that record April low** of eight days in Texas will continue through May, state will have only 135 producing days in '58—**Tight allowable schedules** in other states are also expected to continue.

Liquid Hydrocarbon Reserves Show First Drop Since '43 . . . Reduced oil activity, claimed by many to have been created by excessive imports, resulted in a drop of 349 million barrels in U. S. liquid hydrocarbon reserves last year—the first decline in 15 years (see Page 99). Total reserves, now at 36 billion barrels, were hurt most by smallest addition of new crude discoveries (416.2 million barrels) since 1951.

However, total natural gas reserves increased 8.8 trillion cubic feet to a new high of 246.6 trillion cubic feet.

U. S. Reserve Pattern Is Changing . . . American Petroleum Institute's annual reserves report shows the following shift in U. S. reserve pattern during '57:

- Louisiana (with 3.86 billion barrels) has replaced California (with 3.76 billion) as nation's second largest crude reserve state.
- Four Rocky Mountain states—Montana, North Dakota, Utah, Wyoming—have increased total liquid hydrocarbon reserves from 4.2 to 6.3 percent of U. S. total since 1952. Meanwhile, six top oil and gas liquids states have declined from 88.9 to 87.1 percent of U. S. total.
- Last year, Louisiana proved up 49 percent of nation's new gas discoveries—accounted for 73 percent of nation's gain in total gas reserves (See Page 101).

Washington Panorama . . . Independent oil companies and some government groups have stepped up pressure for mandatory import controls, action one way or the other is expected soon—**Meanwhile, 18 more companies** have asked for hearings so they can put in bids to be included in voluntary imports program—**Strong industry opposition is being mustered** against substitute natural gas bill which would exempt small producers (2 billion cubic feet per day or less), tighten federal fist on major producers—**Three of upcoming items** on U. S. Supreme Court docket involve oil and natural gas: Hearings on Memphis decision are scheduled for next fall, oral arguments in dispute between states and federal government as to states' "historic boundaries" will be held November 13, and decision as to whether Justice Department can proceed in antitrust actions against natural gas companies without waiting for FPC decision is yet to be made.

Continued on Page 91

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LOOKING AHEAD . . .

Will Atoms Revive Depleated Oil Fields? . . . Atomic Energy Commission says it hopes to increase oil supply by heating depleted oil fields with nuclear blasts. According to report, use of nuclear energy would cause crushing action, pulverize oil shale into aggregate, heat it and drive off the oil—would be cheaper than methods now in use.

Question: Possibility exists that such a powerful explosion, if not carefully controlled and made selectively in specific formation, might cause more harm than good. Chances are such a blast would bring in salt water as well as oil.

New York State Delays Offshore Legislation . . . No action on law to permit drilling in New York State offshore areas is expected until '59, despite Pennsylvania's grant of offshore leases in Lake Erie and Ohio's preparation of regulations to allow similar activity. Reason: It will take until next year for full industry reaction to proposed conservation laws governing offshore drilling and underground storage to reach the desks of New York Legislature.

Natural Gas Producer Promotes Solar Heat . . . Anyone who thinks oil and gas people act only in their own self-interest might be hard put to explain recent actions of Godfrey L. Cabot, big producer of natural gas in Appalachian province. Cabot financed a Massachusetts Institute of Technology project to build experimental home in Lexington, Mass., heated with solar energy, with an oil burner installed for use during long cloudy periods. House has glass roof, inclined 60 degrees from horizon, faces south. Occupants will not throw stones.

Deep Test Announced for Bahamas . . . Cay Sal Bank, 180 miles southwest of Nassau, is the site of a wildcat well to be drilled by Bahama California Oil Company and Bahamas Gulf Oil Company. The 15,000-foot test, to be drilled in 30 feet of water, is expected to cost almost $3 million. Main target will be Cretaceous beds.

Needed: More Gas Facilities in the East . . . Insufficient natural gas interstate pipe line capacity became apparent during February cold wave. Many schools and industries, and even some hospitals in Kentucky, Alabama and Georgia were without heat during brief cold snap from February 15-20. Manufactured gas filled gap during peak load days in New York City. Industries were shut down, or slowed down, in Pittsburgh, St. Louis, Youngstown and Cleveland because of greatly increased gas demand.

Paris Basin Opened to Commercial Production? . . . That's what's indicated by a well drilled near Coulomnier, about 20 miles east of Paris, by Petrorep, a French company. On a 75-minute drill stem test, the well yielded 50 barrels of high-gravity crude from the Dogger (Jurassic) at about 6,000 feet. Old joke about Texan's first reaction to the Eiffel Tower (How many barrels a day does that 'un make?) may yet prove to be prophetic.

Venezuelan Junta Assures Smooth Sailing for Oil Interests . . . New Venezuelan government, headed by President Wolfgang Larrazabal, was quick to guarantee the oil industry that previous governmental commitments would be honored and that private enterprise would be encouraged to develop the nation in the future. Three-page statement to oil men concluded, "In this hour of common responsibility, Venezuela offers you guarantees and you owe her cooperation." Undoubtedly "cooperation" means for the U. S. to "lay off of government import controls."

Good Wells Make Good News

A Monthly Report Of Successful Well Treatments

April, 1958

For versatility to meet a wide variety of well conditions, the nine basic Dowell fracturing services deserve serious consideration. Here are some reports on recent treatments showing what has been achieved when the correct service was used.

- **San Juan County, New Mexico.** (Old gas well) This well was completed in the Point Lookout sandstone from 5468 to 5532 feet. Production had decreased to three mmcfd. Before treating with Riverfrac® operator set five-inch liner and perforated six shots per foot. Dowell used nine rubber tanks to hold the water and six Allison pumpers to inject 135,000 gallons fresh water and 50,000 pounds sand *at 110 bpm. On four-hour test after treatment, well produced at the rate of over 36 mmcfd.*

- **Webster Parish, North Louisiana.** (New oil well) This well was completed in the Justiss sandstone through perforations from 9296 to 9321 feet. It swabbed ½ boph before treatment. Working with Dowell, the producer selected a multi-stage treatment designed to prevent troubles from silicate swelling. Treatment was basically Stratafrac®, using acid-kerosene emulsion as fracturing fluid; plus Mud Acid, regular acid with surface tension and silicate control agents, and perforation ball sealers. *After treatment, well potentialed 190 bopd.*

- **Southeastern Saskatchewan, Canada.** (New oil well) This well was completed in the Midale Beds limestone through perforations from 4409 to 4419 feet. After first acidizing, well swabbed 100 per cent water. Following remedial work, a second acid treatment resulted in only 10 to 12 barrels fluid (85 to 90 per cent water) per day. Operator then called in Dowell and ordered Acid Petrofrac®, injecting 5000 gallons acid-oil emulsion and 3000 pounds of sand down casing at 5 bpm. Because of corrosive waters, treatment was spearheaded with Corban® corrosion inhibitor in crude and followed with Corban and Freflo® in crude. *On last test, well was pumping 28 to 30 bopd with only 15 to 20 per cent water.*

- **Wayne County, Ohio.** (New oil well) Completed open hole in the Clinton sand, this well tested only a show of oil and gas. Operator selected Petrojel®, using 8000 gallons jelled crude and 16,000 pounds sand. Injection rate was 28 bpm at 1950 psi. After treatment, load was quickly recovered and *two weeks later the well was flowing 100 bopd with one mmcfd.*

Your Dowell engineer is prepared to give you complete information on any of Dowell's many fracturing services. Call any of the 165 Dowell offices in the United States and Canada; in Venezuela, contact United Oilwell Service. Or write Dowell Incorporated, Tulsa, Oklahoma.

Services for the oil industry DOWELL

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A hazardous risk

THE PRESSURE for sizable reductions in U. S. oil imports has grown substantially and enthusiastically in recent weeks. The reason is as clear as it is simple: U. S. crude oil production is shrinking in the midst of plenty as imports remain on a relatively high level.

And these ills are fast developing in a period when, for the benefit of the entire nation, every industry which can remain healthy in and of itself should be permitted that freedom of success.

U. S. crude oil production in March will be 1⅓ million barrels or 18 percent less than in March, 1957, and at its smallest volume since 1954. Despite government voluntary curbs, imports of crude oil during the four weeks ended March 14 (latest available figures) were 50,900 barrels per day or 3.5 percent greater than in the corresponding period of 1957, and 201,000 barrels per day or 30.6 percent larger than the daily average in 1954. In addition, imports of refined products have risen 36,900 barrels a day or 5.8 percent since a year ago, and 271,000 barrels or 68.5 percent above the average for 1954. Imports of refined products have just as much impact on the domestic market as crude oil imports.

With reason, therefore, domestic producers feel it is not fair or equitable for U. S. production to be curtailed so drastically without corresponding reductions in imports.

Mandatory controls are being sought by a growing segment of the U. S. producing oil industry. An increasing number of producers see mandatory or compulsory controls as the only means of enforcing a reduction in imports. Their fears are intensified by more and more companies asking for import quotas. At least 18 companies who now do not have import quotas have made applications to import approximately 132,000 barrels of crude oil daily.

Many who heretofore have favored high tariffs as the best means of curbing imports now favor mandatory controls. Apparently, this is because there appears to be little possibility of getting Congressional and presidential approval of higher tariffs. Therefore, as a last resort, producers are demanding that compulsory controls be enacted either by Congress or presidential edict. Many favor the former, seeing it as the only way they are likely to procure a permanent stable import basis.

This is a dangerous course, which until now even domestic producers have hesitated to advocate. Oil imports should be curbed. The need is obvious. Imports should not be permitted to supply an increasing portion of the U. S. consumption when domestic production is being curtailed so drastically.

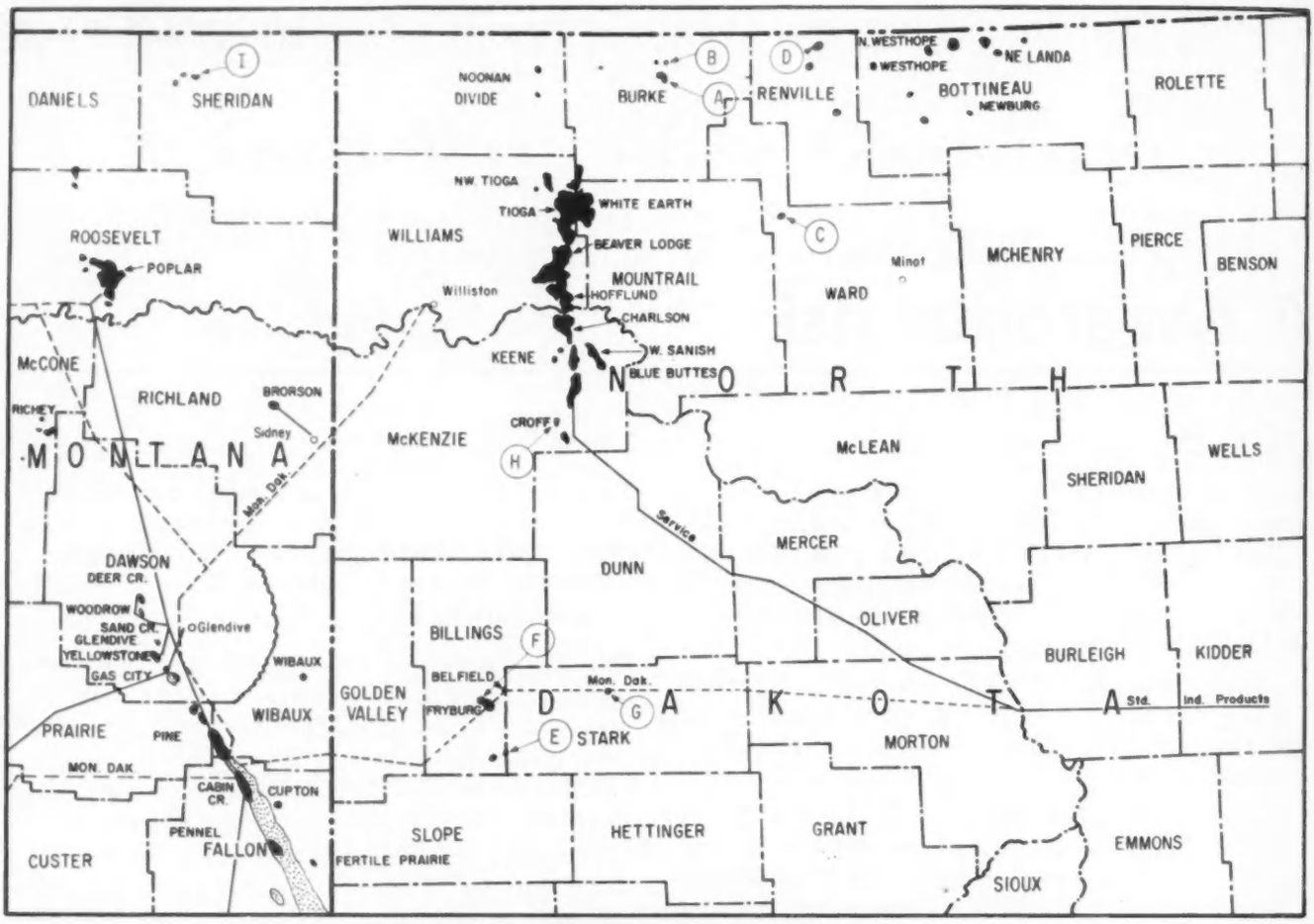
However, mandatory controls are a certain step in the direction of federal control of the domestic oil industry, as well as of imports. Once imports are controlled, there will be demand for equitable regulation of producing rates between states. Some states have been increasing their production, while others, notably Texas, have curtailed their output. Some states prorate to various degrees, while others do not.

Allowables between states can be fixed only by federal control. The federal government never turns loose of anything it gets its hand on. Instead, each bureau inevitably endeavors to increase the scope of its power. The government will be willing to take on the task of regulating U. S. production.

The position of domestic producers is readily understandable. Many of them recognize the danger, but in their present desperate crisis see this hazardous risk as the only way out of their dilemma.

However, mandatory controls are fraught with such danger of complete government control, it behooves all segments of the industry (domestic producers, importers, refiners etc.) to do everything in their power to avoid compulsory control. Each should be sufficiently conscious of his national responsibility to see that a satisfactory answer is found to the import problem which would avoid government control. The industry must be kept free of federal government shackles.

Warren L. Baker



NEW DISCOVERIES IN THE WILLISTON BASIN

The dots indicated by letters mark the nine most significant discoveries in North Dakota and Montana during 1957. The areas are explained as follows: (A) Lignite field, where 13 producers were reported last year. (B) Flaxton field, with three producers and development program now in progress. (C) Hanlon and Williamson's Knudtson 1, Ward County's only producer. (D) Gulf Oil's discovery, only a mile and a half from the Canadian border, may prove out as Renville County's second pool. (E) Northern Pump Company's Fritz 1 in Billings County, was one of southwestern North Dakota's first exploratory successes in 1957. Named Rocky Ridge field, this discovery has reversed the downward trend of interest in the state's "slope" country. (F) In September, successful completion of Scoria 1 marked Billings County's second discovery. (G) Leach Oil et al's Kalanek 1 in Stark County is 20 miles east of all previous production. (H) Amerada's Shelvik 1 in McKenzie County marked an important Nesson anticline development. (I) Amerada's Tange 1 in Sheridan County, Montana, is 29 miles northeast of nearest previous production.

New discoveries boost Williston Basin activity

THE EXCITEMENT that attends success is back again in the U. S. portion of the Williston Basin. After two years of leveling off, exploration has set new records.

Discoveries in three widely separated and relatively unexplored areas of the basin are responsible for today's new interest.

During 1957 discoveries were drilled in the extreme northeastern corner of Montana; in Burke County, North Dakota, east and north of the Nesson anticline, and in the southwest corner of the state.

North Dakota also set a new record for number of discoveries in a single year . . . the 1957 total was 23 . . . and had a wildcat success ratio of 14.92 percent.

The areas in which success came to the Williston in 1957 have been heavily leased for years, with some leaseholds dating from 1949. Since such exploration as had been done prior to last year was not particularly encouraging, some acreage was dropped in 1956. However, 1957 discoveries will force the drilling of acreage still held. Dropped acreage, of course, has been snapped up again.

North Dakota's total of 23 discoveries in 1957 compares with 7 in all of 1956, with 6 in 1955, 4 in 1954, and 13 in 1953. The first 10 months alone in 1957 saw more discoveries drilled than in any previous year in the state's oil history.

Burke County, northeast of the

After leveling off for two years, Williston Basin exploration activity again is setting new records... Box score for 1957:

- **North Dakota set a new record for discoveries—23. Wildcat success ratio averaged 14.9 percent.**
- **In Montana, 34 to 40 rigs were active during last half of year.**
- **For the first time in several years, Williston operators have had to wait on rotaries.**

Beaver Lodge and Tioga fields which are North Dakota's major developments, was and still is the hottest spot in the basin. Discovery of the Lignite field (Area "A" on map) in June began the upward trend of activity in this county. Early test of Northwest Oil Drilling's Bunting 1, did not get an immediate reaction. Similar shows had been found in Burke County before. The discovery is 10 miles southeast of Columbus field — a one-well pool, and 12 miles northwest of another small discovery at Coteau field.

But when the Northwest Oil Drilling wildcat was completed for a flow of 225 barrels of oil per day from the Madison formation it contrasted sharply with small gages of earlier Burke County discoveries.

High flowing potentials. By the end of the year, 13 producers had been completed in Lignite field . . . including two successful wildcats temporarily classified as within the field by the state industrial commission, which has shown considerable optimism as to the potential size of the field.

Early completions at Lignite—(the field takes its name from the town about two miles to the west) were from the Midale zone of the Madison formation. Gages range from 200 to 225 bopd, flowing through chokes averaging about 20/64-inch in size. Typical perforated sections are at 6,078-6,104; 6,094-6,120 and 6,066-96 feet. Later drilling also found oil in Nesson pay.

While early development was in progress at Lignite, Petroleum Corporation of America, Denver, and Tom Jordan, North Dakota independent, started an exploratory program in the area. Three miles southeast of the field their Jorgens 1 was completed for 250 bopd. This discovery found production in the Nesson zone of Madison at 6,276-88 feet and in the Midale at 6,253-61 feet. It was tested in mid-September, added immediate and substantial impetus to exploration. This discovery was one of those temporarily classified as within Lignite field—on a "wait and see" basis.

Additional Burke County discoveries. Seven miles northwest of Lignite field, Arrowhead Exploration, Denver, opened Rival field at 1 Probst. It flowed 56 barrels of oil per hour from the Midale and Nesson zones. Flow was on 30/64-inch choke. This well was drilled on farmout from Pan American Petroleum. First attempt at confirmation was drilled to the north by Pan American. It was a failure. A southwest offset by Mobil Producing was successfully tested in January.

At Olson 1, Northwest Oil Drilling set pipe on strength of Midale and Nesson cores. The well, however, made only 15 barrels of oil with an equal quantity of water at completion.

Petroleum Corporation and Jordan completed another small discovery at Nygaard 1, six miles northeast of Lignite field. It pumped 50 bopd from Nesson.

Another important Burke County success was Petroleum Corporation and Jordan's confirmation of Flaxton field (Area "B" on map), northwest of the town from which it takes its name. Their well, Sorum-A 1, flowed 440 bopd through 24/64-inch choke. It is a west extension to the discovery which was completed by Texota Oil for 80 bopd on pump. By the end of the year, two additional producers had been completed in this field, and a development program was in progress.

Other Burke County discoveries which followed the successful Lignite pool opener included Petroleum Corp. and Jordan's Ballantine 1, which flowed 11 barrels of oil per hour through casing from Mission Canyon; Northwest Oil Drilling and Central Leduc's Klitzke 1, which pumped 40 barrels of oil and 40 barrels of water per day from Midale, and Carter Oil's State-Tande 1, which pumped 66 barrels of oil and 12 barrels of water per day from Madison.

Box score on Burke County. Ten of North Dakota's 23 discoveries listed as officially completed in 1957 are in Burke County. This record resulted from a total of 24 wildcats drilled in the county during the year.

Development drilling in the county accounted for 29 completed wells. Of these, 26 were successfully completed.

Fields in Burke County are credited to a number of factors including variations in permeability and porosity, and very minor structure.

Exploration at the present time is directed to a considerable area north and west of Bowbells in which success has been common. Southeast of present areas of activity, a number of dry holes resulted from earlier drilling.

Demonstration of apparently substantial production in Mississippian prospects east of the Nesson anticline led to drilling in Ward, Renville and Divide counties.

Other counties show activity. In Ward County, W. A. Hanlon and Lowell J. Williamson completed Knudtson 1, (Area "C" on map) NE SE 7-15n-87-w for pump gage of 288 barrels of oil per day from Mission Canyon. This is the county's only producer. It was unsuccessfully offset to the east, but no other drilling has been done closer than a mile to the discovery.

In late January Gulf Oil tested an apparent discovery (Area "D" on map) five miles northeast of Bluell field, Renville County. Bluell is the only field so far developed in the county. Gulf's well, only a mile and a half south of the Canadian border, promises Renville County's second pool.

This area has been most instrumental in record levels of activity in North Dakota. At the end of 1957, more than 50 rotaries were working in the state. This is by comparison a remarkably high rate of activity for

winter months and a near record at any season.

Discoveries in southwest section. Southwestern North Dakota had one of the first exploratory successes of the year, but later work moved more slowly than it did in Burke County. Northern Pump Company completed Fritz 1, Billings County, for a flowing rate of 1,224 barrels per day from perforations in Heath 8,055-72 feet. Flow was on 24/64-inch choke.

This discovery (Area "E" on map) is 12½ miles south of Fryburg field, earliest production in the southwest part of the state. Fryburg has both Heath and Madison production, but did not develop into a major field, and following scattered exploration through this part of the state, some southwestern North Dakota leases had been dropped.

Rocky Ridge field, as the Northern Pump discovery was designated, reversed the downward trend of interest in the state's "Slope" country.

The first two extensions drilled at Rocky Ridge dampened to some degree the enthusiasm built by the discovery. Sun Oil and Skelly Oil drilled failures to the southeast. However, later in the year two successes were drilled to the northwest, indicating that the discovery may have been made at the southern end of a considerable trend.

In September Billings County was again in the headlines. Amerada Petroleum had a flow of 109 barrels of oil in 13 hours on test of Heath at Scoria Unit (Area "F" on map). Test of Madison at this well flowed 231 barrels of oil and 11 barrels of water in 23 hours. Both tests were on chokes of less than one-half inch. Heath production is from the zone 7,966-76 feet, and Madison production from 9,213-58 feet. The discovery has since been successfully confirmed.

The Scoria discovery is four miles west of Fryburg field and 15 miles northwest of Rocky Ridge.

This wasn't the whole story for the southwestern corner of the state. Leach Oil and others completed Kalanek 1, (Area "G" on map) Stark County, for a pump gage of 140 barrels of 25 gravity oil cutting 10 percent. Production is from 8,800-10 feet in Nesson pay. This discovery is 2 miles northwest of the town of Dickinson, and 20 miles east of any previous production. The excitement resulting was to a degree reminiscent of the early days of activity in the state.

A second well at Dickinson failed to find commercial production in the Nesson (Madison), but was completed as a new pay discovery from Heath. It was drilled by The Atlantic Refining Company and Goodstein Oil.

Skelly Oil, Northern Pump and Texota Oil are also active in Stark County.

Pan American Petroleum was at the end of January near completion on an 11,000-foot test of the Winnipeg at a Morton County wildcat. No drilling had been done in this county for some time.

New activity in Nesson anticline. These newly developed hot spots in North Dakota skip some very important activity at the southern end of the Nesson anticline, some renewed work in Divide County and deep drilling in the Beaver Lodge-Tioga areas of the Nesson where as many as 11 different pay zones have been proved at depths to 12,000 feet.

One important Nesson anticline development which was near final tests at the end of January is Amerada Petrolem's 1 Shelvik, (Area "H" on map) McKenzie County. Oil was recovered on drill stem test of Silurian from 12,622-12,670 feet. The well is on the western flank of the anticline and six miles southwest of Fancy Buttes field. It is the most southerly promise of Silurian production in North Dakota.

N. E. Montana also active. While North Dakota drilling — moving up in all sections of the state — was setting a new record in 1957, the Montana portion of the basin developed a few "hot spots" of its own.

Early in the year—about the same time that Northern Pump made its Billings County, North Dakota, discovery — Amerada Petroleum completed Tange 1 (Area "I" on map), Sheridan County, Montana, for a flow of 2,742 barrels per day of 40 gravity oil through half-inch choke. Production is from an 18-foot section of Silurian at 9,056-74 feet.

This discovery is 1½ miles north of the town of Outlook and 29 miles northeast of nearest previous production in northeast Bredette field, Daniels County.

Long range appraisal of extreme northeastern Montana changed following the Amerada discovery. The area, under lease for some time, had been the scene of considerable geophysical work, but little exploration had been done below Mississippian. Shows, if any, were small. The area had been mentally relegated to the most remote corner of the Williston Basin backyard.

When Amerada's next two wildcats in the same general area also came in as producers, one in Silurian and one in Red River (Ordovician)—it become obvious that northeastern Montana was definitely not going to be overlooked in future activity.

Amerada has kept two rigs busy, and exploration has been done or is in progress in the county by The Texas Company, Pan American Petroleum, Gulf Oil, American Petrofina and Carter Oil. So far Amerada has a monopoly on success.

Reservoir conditions "uncertain." This area has had a relatively cautious approach. Some of the "tricky" reservoir conditions elsewhere in the basin were fresh in the minds of operators. It appears now that a substantial program which will gain momentum steadily but comparatively slowly is in the offing. How fast drilling accelerates depends on continuing evaluation of Amerada's work, and no definite evaluation has as yet been made public. Recent drilling results have been mixed, with the area successful on balance.

Success in the northeastern corner of Montana subsequently has caused an increase in activity in northern Roosevelt County, and in Garfield and Valley counties a considerable distance west of Amerada's discovery at Outlook.

Near Record Montana activity. Because of this, it probably is surprising to some observers that Montana activity in 1957 was only a little behind the state's record year. As already noted, North Dakota drilling set new records.

In Montana, 34 to 40 rotaries were active through the last half of 1957. North Dakota's average rig activity during the same time has been closer to 40 units, but with peaks of 50 or more in the late part of the year—unusual under winter conditions. For the first time in several years operators in the Williston Basin have had to wait on rotaries—sometimes for a considerable time after a deal is put together. —The End

Earnings due to lag in 1958 after 1957 latter half drop

By L. J. Logan, WORLD OIL Staff

OIL COMPANY earnings reflect the lagging of demand for petroleum products and the resultant curtailment of industry operations.

It probably will be next fall, at earliest, before reported earnings can appear favorable in year-to-year comparisons. In October and November the quarterly reports for the three months ending September 30, 1958, will be issued. They possibly may show earnings equaling or comparing favorably with those in the similar period of 1957.

It now appears possible that fourth quarter earnings of 1958 will exceed those of 1957. But it is doubtful that profits for the year 1958 will equal those of 1957.

It is to be expected that decreases from last year will be reported in July and August for the second quarter of 1958, because of lagging volumes of oils produced and sold.

Sharp declines in earnings, ranging possibly from 20 to 50 percent, and averaging maybe 30 percent, will be reported in April and May, when first quarter statements are issued. The results for the period must be compared with those in the highly profitable initial quarter of 1957.

For the first quarter of 1958, refining companies may show the largest decreases, producers the smallest, and integrated companies average declines. Markets for products have been weak. Crude prices have weakened only to limited extent, but volumes of crude produced have been low.

For the fourth quarter of 1957, 40 oil companies together reported 12.6 percent less profit than in the final quarter of 1956. (See table.) That large decrease reflected lagging domestic demand for oils, normal exports versus Suez crisis exports a year earlier, lower product and crude prices, and higher operating costs.

In the third quarter of 1957, 52 oil companies reported earnings down 6.9 percent from 1956. (WORLD OIL, December, 1957, Page 89.)

The decreases in earnings in the third and fourth quarters of 1957 largely canceled out the gains that were made in the first and second quarters. For the year 1957, 40 oil companies reported 2.8 percent more profit than in 1956. (See the table herewith.)

For last year's first half 43 oil companies earned 17.0 percent more than in the initial half of 1956. (WORLD OIL, September 1957, Page 70.) Their second quarter profits were up 16 percent. First quarter profits were up 19 percent for 49 companies. (WORLD OIL, June 1957, Page 112.)

Although 40 companies together had a decrease of 12.6 percent in earnings in the fourth quarter of 1957, 17 showed increases. Prominent among the gainers were several West Coast and Middle West companies and a few crude producers. Fourth quarter profits were down moderately to sharply for a majority of the refiners and integrated companies.

—The End

Annual and Fourth Quarter Net Earnings of Some Oil Companies, 1957 vs. 1956

(All "per share" data based on number of shares of common stock outstanding December 31, 1957.)

COMPANY	ANNUAL EARNINGS					4th QUARTER EARNINGS				
	Total $Thousand		$Per Share		%	Total $Thousand		$Per Share		%
	1957	1956	1957	1956	Dif.	1957	1956	1957	1956	Dif.
Am. Maracaibo	3,094	2,565	.84	.69	+21	448	528	.12	.14	— 15
Andrson-Prich	5,243	5,880	2.93	3.41	—11	1,168	1,651	.65	.92	— 29
Argo Oil	4,921	4,509	2.51	2.30	+ 9	1,125	1,100	.57	.56	+ 2
Ark. Fuel	8,636	7,525	2.27	1.98	+15	2,718	1,779	.71	.47	+ 53
Ashland O & R	15,544	14,234	2.39	2.19	+ 9	3,575	4,250	.55	.65	— 16
Atlantic Ref	35,700	47,157	3.97	5.25	—24	6,406	14,466	.71	1.61	— 56
Aztec O & G	1,003	626	.44	.27	+60	283	239	.12	.15	— 18
Bishop Oil	267	438	.47	.78	—39	105	130	.18	.23	— 19
Champlin	9,704	9,479	2.28	2.23	+ 2	2,455	2,737	.58	.65	— 10
Cities Service	59,179	62,152	5.63	5.91	— 5	13,523	18,660	1.29	1.77	— 27
Clark O & R	1,422	2,486	1.07	1.81	—43	338	465	.25	.35	— 27
Continental	46,724	51,817	2.38	2.64	—10	11,862	12,675	.60	.65	— 7
§Gulf Oil	354,284	282,658	11.38	9.08	+25	102,263	68,629	3.28	2.20	+ 49
Honolulu Oil	14,538	13,816	3.88	3.68	+ 5	3,247	3,228	.87	.86	+ 1
*Humble O & R	175,900	178,961	2.45	2.49	— 2	†68,112	†86,601	†.95	†1.21	†— 21
*Imperial Oil	72,000	69,099	2.29	2.20	+ 4	13,579	17,961	.43	.57	— 24
*Intrnatl Pet	41,100	38,247	2.83	2.63	+ 8	10,000	9,547	.69	.66	+ 5
Midwest Oil	6,755	6,559	2.66	2.58	+ 3	1,568	1,556	.62	.61	+ 1
Ohio Oil Co	41,490	41,216	3.16	3.14	+ 1	9,483	10,920	.72	.83	— 13
Phillips Pet	96,209	95,203	2.80	2.77	+ 1	21,982	23,632	.64	.69	— 7
Plymouth Oil	6,027	7,956	2.40	3.17	—24	372	1,971	.15	.79	— 81
Pure Oil Co	35,524	36,560	4.13	4.25	— 3	9,377	10,350	1.09	1.20	— 10
Quaker State	1,983	1,975	2.40	2.39	+ 1	392	307	.48	.37	+ 28
Richfield Oil	28,176	26,574	7.04	6.64	+ 6	6,402	5,805	1.60	1.45	+ 10
Seaboard Oil	11,159	9,369	3.05	2.56	+19	2,431	1,839	.66	.50	+ 32
Shell Oil Co	135,085	135,848	4.46	4.49	— 1	29,287	35,704	.97	1.18	— 18
Signal O & G	13,052	10,694	3.03	2.48	+22	3,765	3,648	.87	.85	+ 3
*Sinclair Venez	10,057	9,152	2.51	2.28	+10	3,893	2,202	.97	.55	+ 77
Skelly Oil	36,785	34,093	6.40	5.93	+ 8	8,554	10,749	1.49	1.87	— 20
Socony Mobil	220,000	249,504	4.62	5.25	—12	37,000	66,504	.78	1.40	— 44
Standard, Cal	288,230	267,891	4.56	4.24	+ 8	76,465	77,536	1.21	1.23	— 1
Standard, Ind	151,509	149,432	4.24	4.18	+ 1	37,637	34,441	1.05	.96	+ 9
Standard, Ky	12,626	12,478	4.85	4.79	+ 1	3,067	2,917	1.17	1.12	+ 5
Standard, N. J	800,000	808,535	4.07	4.11	— 1	140,000	205,535	.71	1.04	— 32
‡Standard, Ohio	23,920	26,592	4.79	5.35	—10	9,338	6,433	1.93	1.33	+ 45
Sun Oil Co	47,492	56,160	4.17	4.93	—15	8,478	16,363	.74	1.44	— 48
ΙSunray Mid-Cont	56,400	45,310	3.04	2.40	+25	11,400	13,910	.61	.75	— 18
Texas Gulf Prod	6,442	5,658	1.60	1.40	+14	1,482	1,231	.37	.31	+ 20
Texas PC & O	7,232	7,210	2.01	2.00	+ 1	1,717	1,704	.48	.47	+ 1
The Texas Co	332,304	302,263	5.94	5.40	+10	89,200	94,833	1.59	1.70	— 6
Union of Cal	38,236	34,241	4.95	4.44	+12	10,560	8,133	1.37	1.05	+ 30
Universal Consol	3,563	3,355	3.72	3.50	+11	823	894	.86	.93	— 8
Wilcox Oil	891	783	3.02	2.65	+14	214	94	.72	.32	+129
Woodley Pet	3,290	2,233	4.17	2.83	+47	744	692	.94	.87	+ 7
*Total, 40 Companies	2,964,639	2,883,034	....	....	+ 3	671,254	768,238	....	....	— 13

* Humble, Imperial and International Pet. are excluded from totals, being included as affiliates of Standard (N.J.). Sinclair Venezuelan also is excluded from totals, being a Venezuelan affiliate of Sinclair Oil Corp.

† Latter half of year.

‡ Standard (Ohio) earnings for year 1957 and fourth quarter of 1957 include non-recurring profit of $1,685,000 or 35 cents per share.

§ Gulf Oil Corp.'s earnings for year 1957 and 4th quarter of 1957 include non-recurring profit from sale of Texas Gulf Sulphur Co. stock, which was $30,685,701 (99 cents per share) before taxes.

ΙSunray for year 1957 includes capital gain of $9 million, or 52 cents a common share.

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CHANGING PANORAMA

U. S. liquid hydrocarbon supply shows first drop in 15 years

By **Don E. Lambert,** WORLD OIL Staff

TOTAL U. S. proved reserves of liquid hydrocarbons followed the general downturn in oil industry activity during 1957. And Louisiana replaced California as the nation's second largest crude reserve state. The picture in brief:

- Proved reserves of crude oil and natural gas liquids totaled nearly 36 billion barrels, 349 million barrels (0.97 percent) below the peak year of 1956. This was the first time a decline has been reported since 1943.
- Operators proved up 2.56 billion barrels of new liquid hydrocarbon reserves, the smallest total since 1946.
- Total production set a new record at 2.9 billion barrels, slightly more (13.5 million barrels) than was produced in 1956.
- With a big assist from offshore discoveries, Louisiana moved ahead of California by nearly 98 million barrels in total proved crude reserves. The state's total at the end of 1957 was 3.86 billion barrels, compared with California's 3.76 billion.
- Athough the six top liquid hydrocarbon states have increased total proved reserves 2 billion barrels (from 29.3 to 31.3 billion barrels) since 1952, their portion of the U. S. total has declined from 88.9 to 87.1 percent. During this five-year period, four Rocky Mountain states— Montana, North Dakota, Utah and Wyoming—have increased their portion of the U. S. reserve total from 4.2 to 6.3 percent.
- Canada reported a substantial increase in crude and natural gas liquids reserves, bringing its new total to a record high of 3.27 billion barrels. Operators developed 324.6 million barrels of new reserves while producing 184.8 million.

These statistics are based on the 1957 annual reserve report prepared by the American Petroleum Institute. The figures on Canada were reported originally by the Canadian Petroleum Association.

Less crude was added. For the fourth consecutive year, API reported a decrease in additions to proved crude oil reserves during 1957. An estimated 2.4 billion barrels of new crude was proved up, 500 million barrels less than the previous year, for the smallest total in more than 12 years. Total crude reserves was reported at 30.3 billion barrels, a decrease of 134.2 million barrels from 1956.

Natural Gas Liquids. U. S. reserves of natural gas liquids totaled 5.7 bil-

TABLE 1—Summary of Changes in 1957 in Proved U. S. Reserves of Liquid Hydrocarbons
Sources: Crude oil from API; natural gas liquids from API and AGA
(THOUSANDS OF BARRELS)

	Crude Oil	Natural Gas Liquids	Total Liquid Hydrocarbons
Total proved reserves, December 31, 1956	30,434,649	5,902,332	36,336,981
Revisions of previous estimates and extensions of old pools	2,008,603	8,884	2,017,487
New reserves discovered in 1957 in new fields and in new pools in old fields	416,197	128,508	544,705
Proved reserves added in 1957	2,424,800	137,392	2,562,192
Total proved reserves, December 31, 1956 plus new proved reserves added in 1957	32,859,449	6,039,724	38,899,173
* Less production during 1957	2,559,044	352,364	2,911,408
Total proved reserves December 31, 1957	30,300,405	5,687,360	35,987,765
Change in reserves during 1957	—134,244	—214,972	—349,216

* The 1957 production figures were compiled by the committee from records of actual production for whatever period such were available, with estimates for the remainder of the year. Any variance between the actual production, as later reported, and the figures used herein will be compensated for through revision when the following year's reserve report is compiled. These revisions have in the past been very small. Because, in each annual report by this committee, the production figure for the year is an estimate, as just explained, correct total cumulative production cannot be obtained by adding together the figures listed in successive reports of this committee, or in the columns marked "production" of Table 3.

TABLE 2—Total U. S. Liquid Hydrocarbon Reserve Changes Past 5 Years

	PROVED RESERVES (Thousands of Barrels)		RATIO OF YEAR END RESERVES TO YEAR'S PRODUCTION		PERCENT OF U. S. RESERVES		PERCENT OF U. S. PRODUCTION	
STATES	End of 1957	End of 1952	1957	1952	1957	1952	1957	1952
Alabama[1]	34,409	15,635	5.4	14.4	0.09	.04	0.22	.04
Arkansas	342,099	403,132	10.5	14.0	0.95	1.23	1.11	1.13
California[2]	4,065,483	4,176,678	11.0	10.7	11.30	12.67	12.67	15.31
Colorado	320,904	317,030	5.8	10.2	0.89	.96	1.91	1.21
Illinois	666,539	639,707	8.6	9.9	1.85	1.94	2.68	2.54
Indiana	66,850	55,704	5.6	4.7	0.19	.17	0.41	.47
Kansas	1,136,639	1,085,216	8.7	9.0	3.16	3.29	4.47	4.74
Kentucky	143,747	64,723	7.5	4.8	0.40	.20	0.66	.53
Louisiana	4,876,767	3,271,196	14.1	12.4	13.55	9.93	11.86	10.38
Michigan	50,729	57,994	4.9	4.3	0.14	.17	0.36	.53
Mississippi	413,951	409,740	10.4	10.5	1.15	1.24	1.37	1.53
Montana	327,796	159,310	12.0	16.1	0.91	.49	0.94	.39
Nebraska	70,194	24,552	3.4	9.6	0.19	.07	0.71	.10
New Mexico	1,152,292	884,901	10.7	12.6	3.21	2.69	3.70	2.75
New York	37,533	52,854	14.1	12.6	0.10	.16	0.09	.17
North Dakota[1]	280,921	76,203	19.6	53.7	0.78	.23	0.49	.06
Ohio	69,960	29,168	12.6	8.6	0.19	.09	0.19	.13
Oklahoma	2,284,164	1,842,526	9.3	8.6	6.35	5.59	8.44	8.47
Pennsylvania	129,950	124,364	15.6	10.9	0.36	.38	0.28	.45
Texas[2]	17,826,757	18,041,259	14.2	15.5	49.54	54.74	43.16	45.84
Utah	140,125	42,456	30.4	24.9	0.39	.13	0.16	.07
West Virginia	75,457	56,740	10.6	7.2	0.21	.17	0.24	.31
Wyoming	1,470,883	1,121,812	13.1	15.1	4.09	3.40	3.86	2.82
Miscellaneous[3]	3,616	4,305	5.5	8.0	0.01	.02	0.02	.03
Total U. S.	35,987,765	32,957,205	12.4	13.0	100.00	100.00	100.00	100.00

[1] Crude oil only.
[2] Includes offshore reserves.
[3] Includes Alabama and North Dakota natural gas liquids; Missouri, Tennessee and Virginia crude; and Florida crude and natural gas liquids.

TABLE 3—Estimated Proved Reserves of Liquid Hydrocarbons in U. S. and Canada, by Areas
Sources: For U. S., crude oil from API and natural gas liquids from API and AGA. For Canada, all data via API from Canadian Petroleum Association.

THOUSANDS OF BARRELS

STATE or PROVINCE	Proved Reserves Dec. 31 1956	Added in 1956 by Extensions and Revisions	[1]Discovered in 1956 in New Fields and New Pools in Old Fields	[2]Production During 1957	Proved Reserves Dec. 31, 1957 (Columns 1 + 2 + 3 Less Column 4)	Changes in Reserves During 1957 (Column 5 Less Column 1)
	(1)	(2)	(3)	(4)	(5)	(6)
UNITED STATES Crude Oil						
Alabama	37,537	3,301	.....	6,429	34,409	—3,128
Arkansas	317,726	14,593	2,271	29,631	304,959	—12,767
California[3]	3,771,357	312,412	15,060	339,075	3,759,754	—11,603
Colorado	363,750	—1,577	2,645	54,879	309,939	—53,811
Illinois	700	23,765	7,172	76,191	654,746	—45,254
Indiana	67,728	10,585	241	11,818	66,736	—992
Kansas	992,211	65,399	13,654	123,780	947,484	—44,727
Kentucky	148,442	4,361	2,541	17,304	138,040	—10,402
Louisiana[3]	3,675,419	376,360	104,259	298,469	3,857,569	182,150
Michigan	55,312	2,273	2,182	10,275	49,492	—5,820
Mississippi	368,205	18,590	9,697	36,942	359,550	—8,655
Montana	331,414	14,628	940	26,991	319,991	—11,423
Nebraska	62,861	11,821	8,038	19,661	63,059	198
New Mexico	835,437	76,992	11,750	92,435	831,744	—3,693
New York	40,196	.....	.....	2,663	37,533	—2,663
North Dakota	195,834	19,083	56,340	13,036	258,221	62,387
Ohio	63,575	10,128	.....	5,553	68,150	4,575
Oklahoma	2,009,798	125,181	17,989	211,447	1,941,521	—68,277
Pennsylvania	134,700	.....	.....	8,210	126,490	—8,210
Texas[3]	14,783,139	699,718	129,541	1,057,258	14,555,140	—227,999
Utah	61,435	61,572	21,635	4,608	140,034	78,599
West Virginia	51,221	3,539	.....	2,215	52,545	1,324
Wyoming	1,363,164	155,884	10,192	109,522	1,419,718	56,554
Miscellaneous[4]	4,188	—5	50	652	3,581	—607
Total U.S.	30,434,649	2,008,603	416,197	2,559,044	30,300,405	—134,244
[5]Natural Gas Liquids						
Alabama[6]	.....	.....	.....	.....	.....	.....
Arkansas	42,467	—2,501	89	2,915	37,140	—5,327
California[3]	311,728	23,085	585	29,669	305,729	—5,999
Colorado	11,545	173	80	833	10,965	—580
Illinois	16,772	—3,255	.....	1,724	11,793	—4,979
Indiana	133	—3	5	21	114	—19
Kansas	171,615	21,698	2,191	6,349	189,155	17,540
Kentucky	7,251	275	138	1,957	5,707	—1,544
Louisiana[3]	1,014,942	—10,580	61,895	47,059	1,019,198	4,256
Michigan	1,068	246	19	96	1,237	169
Mississippi	56,003	1,016	398	3,016	54,401	—1,602
Montana	8,145	—13	.....	327	7,805	—340
Nebraska	6,504	1,364	78	811	7,135	631
New Mexico	414,099	—82,570	4,343	15,324	320,548	—93,551
North Dakota	19	.....	5	1,300	22,700	3,700
Ohio	1,669	144	16	19	1,810	141
Oklahoma	355,588	7,334	13,818	34,097	342,643	—12,945
Pennsylvania	3,167	261	131	99	3,460	293
Texas[3]	3,379,889	51,756	38,955	198,983	3,271,617	—108,272
Utah	95	.....	.....	4	91	—4
West Virginia	26,741	798	266	4,893	22,912	—3,829
Wyoming	53,874	—346	501	2,864	51,165	—2,709
Miscellaneous[7]	37	2	.....	4	35	—2
Total U.S.	5,902,332	8,884	128,508	352,364	5,687,360	—214,972
[8]Total Liquid Hydrocarbons						
Alabama[9]	37,537	3,301	.....	6,429	34,409	—3,128
Arkansas	360,193	12,092	2,360	32,546	342,099	—18,094
California[3]	4,083,085	335,497	15,645	368,744	4,065,483	—17,602
Colorado	375,295	—1,404	2,725	55,712	320,904	—54,391
Illinois	716,772	20,510	7,172	77,915	666,539	—50,233
Indiana	67,861	10,582	246	11,839	66,850	—1,011
Kansas	1,163,826	87,097	15,845	130,129	1,136,639	—27,187
Kentucky	155,693	4,636	2,679	19,261	143,747	—11,946
Louisiana[3]	4,690,361	365,780	166,154	345,528	4,876,767	186,406
Michigan	56,380	2,519	2,201	10,371	50,729	—5,651
Mississippi	424,208	19,606	10,095	39,958	413,951	—10,257
Montana	339,559	14,615	940	27,318	327,796	—11,763
Nebraska	69,365	13,185	8,116	20,472	70,194	829
New Mexico	1,249,536	—5,578	16,093	107,759	1,152,292	—97,244
New York[9]	40,196	.....	.....	2,663	37,533	—2,663
North Dakota	214,834	19,083	61,340	14,336	280,921	66,087
Ohio	65,244	10,272	16	5,572	69,960	4,716
Oklahoma	2,365,386	132,515	31,807	245,544	2,284,164	—81,222
Pennsylvania	137,867	261	131	8,309	129,950	—7,917
Texas[3]	18,163,028	751,474	168,496	1,256,241	17,826,757	—336,271
Utah	61,530	61,572	21,635	4,612	140,125	78,595
West Virginia	77,962	4,337	266	7,108	75,457	—2,505
Wyoming	1,417,038	155,538	10,693	112,386	1,470,883	53,845
Miscellaneous[10]	4,225	—3	50	656	3,616	—609
Total U.S.	36,336,981	2,017,487	544,705	2,911,408	35,987,765	—349,216
CANADA Crude Oil						
Northwest Territories	53,258	.....	.....	400	52,858	—400
British Columbia	2,482	—716	661	334	2,093	—389
Alberta	2,389,296	77,761	33,124	139,248	2,360,933	—28,363
Saskatchewan	358,693	90,827	5,982	35,045	420,457	61,764
Manitoba	42,005	—1,677	10	6,080	34,258	—7,747
Ontario	3,524	820	46	627	3,763	239
New Brunswick	112	—1	.....	19	92	—20
Total Crude Oil	2,849,370	167,014	39,823	181,753	2,874,454	25,084
Total Natural Gas Liquids	279,934	100,731	17,020	3,025	394,660	114,726
Total Liquid Hydrocarbons In Canada	3,129,304	267,745	56,843	184,778	3,269,114	139,810

[1] Limited area assigned to a discovery until proved larger. [2] See footnote to Table 1. [3] Includes off-shore reserves. [4] Ariz., Fla., Mo., Nev., S.D., Tenn., Va., Wash. [5] Condensate, natural gasoline, LPG. [6] Incl. in Miscl. [7] Ala., Fla., [8] Crude oil and natural gas liquids. [9] Crude oil only. [10] Ala. natural gas liquids; Ariz., Nev., S. D., Tenn., Wash. and Va. crudes; and Fla. crude and natural gas liquids.

lion barrels at the end of 1957, a decrease of 215 million barrels (3.7 percent) from 1956.

New reserves proved up during the year (including extensions and revisions) totaled 137.4 million barrels, the smallest total since 1946. However, discoveries of new pools and fields added the largest volume of natural gas liquids—128.5 million barrels—to the total reserves since 1946. This compares with a 94 million barrel increase in 1956 over the previous year.

Texas had biggest decrease. Seventeen of the 23 crude and natural gas liquids producing states reported decreases in total reserves during 1957, compared with only eight states showing decreases in 1956.

Despite a sharp curtailment in producing days, Texas reported the biggest decrease in total reserves in recent years: 336.3 million barrels less than the total of 18.2 billion barrels of reserves in the ground at the end of 1956.

Five-year comparison. The API report shows a small but significant shift in the U. S. reserve pattern since 1952. During this period, total U. S. liquid hydrocarbon reserves have increased from 33 to 36 billion barrels. Louisiana accounted for 53 percent of the 3 billion barrel increase, boosting its total reserves from 3.3 billion barrels to 4.9 billion since 1952. The state now accounts for 13.5 percent of U. S. total reserves, compared with 9.9 percent five years ago.

During this same period, Texas has dropped from 54.7 to 49.5 percent of the total U. S. reserves. California decreased from 12.7 to 11.3 percent and Kansas from 3.3 to 3.2 percent. New Mexico increased its total reserves from 2.7 percent of the U. S. total to 3.2 percent and Oklahoma increased from 5.6 to 6.3 percent.

On the other hand, four states—Montana, North Dakota, Utah and Wyoming—are now accounting for a larger portion of total U. S. reserves. At the end of the year, these states reported 2.2 billion barrels of liquid hydrocarbon reserves, an increase of 820 million barrels in the past five years. Their portion of the U. S. total has increased from 4.2 to 6.2 percent.

—The End

Natural gas reserves reach new high during 1957

Louisiana operators proved up 49 percent of the nation's new gas discoveries—and accounted for 73 percent of the nation's gain in total reserves.

DURING 1957 U.S. natural gas reserves increased 8.8 trillion cubic feet to a new record total of 246.6 trillion cubic feet. This was the fourth largest annual increase in the natural gas industry's history.

The new record was achieved even though production set a new record of 11.5 trillion cubic feet, an increase of 6 billion cubic feet over the previous peak reported in 1956.

A substantial portion of the increase resulted from a record year for new discoveries. An estimated 9 trillion cubic feet of new reserves were proved up through discovery of new fields and pools last year. The previous high was 7 trillion cubic feet proved up in 1953.

Extensions and revisions of earlier estimates and additions to underground storage totaled 11.3 trillion cubic feet, bringing the total additions to natural gas reserves to 20.3 trillion cubic feet. This was the fourth largest addition to reserves in the industry's history.

Louisiana sets record. A record year for new discoveries—4.4 trillion cubic feet—made Louisiana by far the leading contributor to the nation's reserve total last year. In fact, Louisiana's new discoveries accounted for 49 percent of the new U.S. record of 9 trillion cubic feet.

Even though Louisiana operators produced the second largest volume of natural gas in the U.S. last year (2.1 trillion cubic feet), the state still added 6.4 trillion cubic feet of new reserves to the state's total. This represented 73 percent of the nation's gain in natural gas reserves last year.

Texas, the nation's largest natural gas state, proved up 5.9 trillion cubic feet of natural gas reserves while producing 5.5 trillion cubic feet, adding 355 billion cubic feet to its reserves total.

TABLE 1

Summary of Changes in 1957 in Proved U. S. Reserves of Natural Gas

(Source: American Gas Association)
Millions of Cubic Feet—14.65 psia, at 60° F.

Total proved reserves as of December 31, 1956..	237,774,569
Extensions and revisions of previous estimate during the year of 1957	11,118,319
New reserves discovered in 1957	8,998,993
Net changes in underground storage during 1957.	179,733
Total proved reserves added and net changes in underground storage during 1957	20,297,045
Total proved reserves as of December 31, 1956 and additions during 1957	258,071,614
Deduct production during 1957	11,502,359
Total proved reserves of natural gas as of December 31,1957	246,569,255
Increase in reserves during 1957	8,794,686

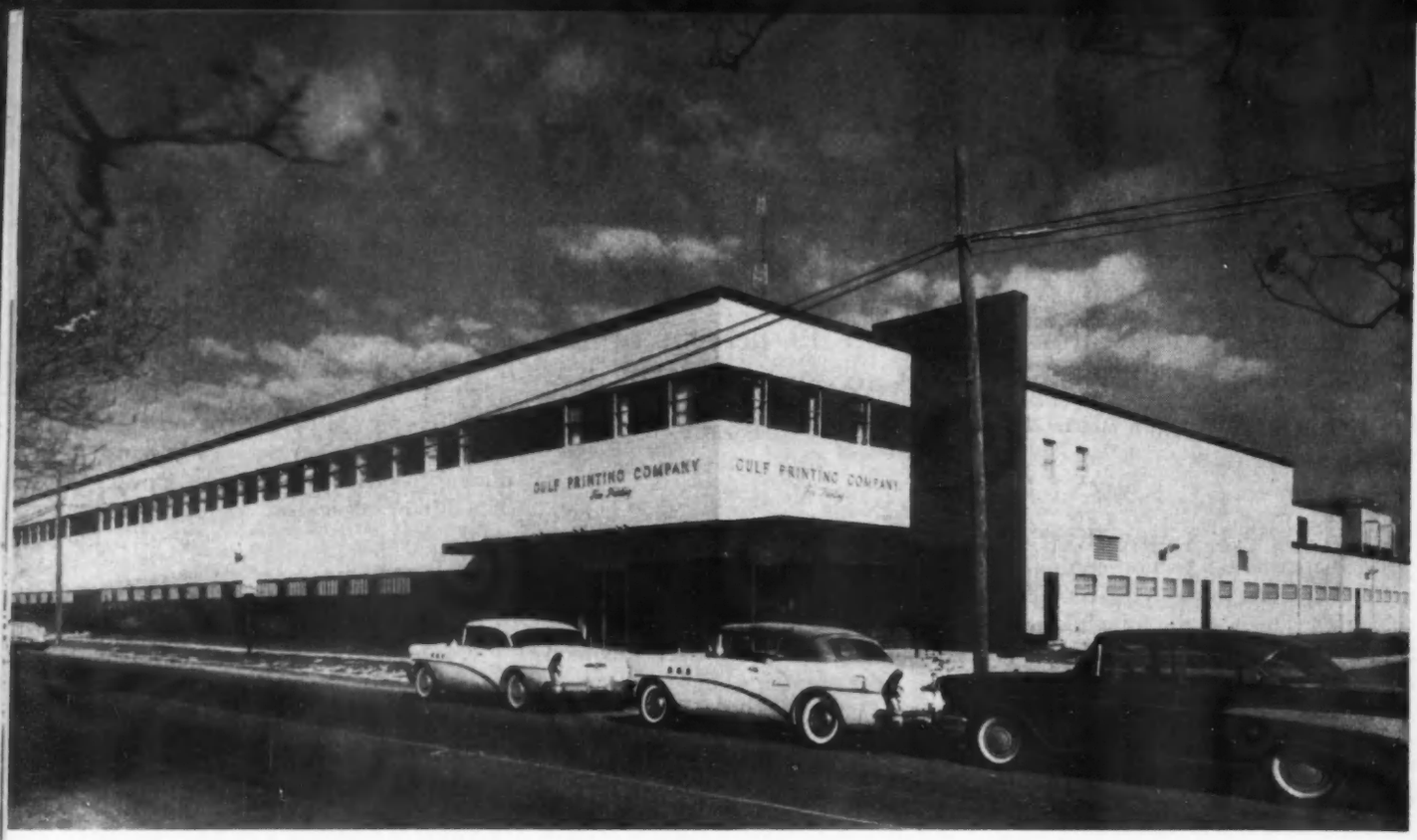
TABLE 2—Estimated Proved Recoverable Reserves of Natural Gas in U. S., by States

Source: American Gas Association
(Millions of Cubic Feet—14.65 psia, at 60 deg. F)

STATE	[2]Reserves As of December 31, 1956	CHANGES IN RESERVES DURING 1957				RESERVES AS OF DECEMBER 31,1957				
		[2]Extensions and Revisions	[2]Discoveries of New Fields and New Pools in Old Fields	[3]Net Change in Underground Storage	[4]Net Production	Total (Columns 7+8+9+10 Also Columns 1+2+3+4 Less Column 5)	[5]Non-Associated	[6]Associated	[7]Dissolved	[8]Underground Storage
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Arkansas	1,171,527	103,994	47,818	145	40,462	1,283,022	746,150	294,187	237,943	4,742
[9]California	8,751,233	516,043	144,989	12,616	471,988	8,952,893	2,387,342	2,035,866	4,451,261	78,424
Colorado	2,422,769	40,381	55,244	1,385	139,100	2,380,679	1,689,189	120,895	565,919	4,676
Illinois	219,705	—36,175	0	2,085	19,243	166,372	5,442	500	130,701	29,729
Indiana	33,772	0	270	950	4,040	30,952	1,750	1,680	19,351	8,171
Kansas	17,566,257	2,136,392	218,473	565	625,709	19,295,978	18,628,827	283,726	236,227	57,198
Kentucky	1,245,602	43,714	7,640	—2,911	69,000	1,225,045	1,142,060	0	64,117	18,868
[9]Louisiana	45,053,999	4,137,189	4,366,891	0	2,122,125	51,435,954	40,804,849	7,474,784	3,156,321	0
Michigan	361,786	46,625	1,750	44,015	10,148	444,028	84,941	22,788	58,192	278,107
Mississippi	2,403,326	70,809	28,983	462	205,840	2,297,740	1,551,952	475,940	276,171	2,677
Montana	696,351	649	957	4,324	31,831	670,450	515,382	40,823	79,140	35,105
Nebraska	225,402	—9,014	1,734	0	28,783	189,339	114,997	12,315	62,027	0
New Mexico	23,472,707	—684,776	215,588	—1,684	743,826	22,258,009	16,675,018	4,055,991	1,477,156	49,844
New York	85,249	3,200	800	7,249	3,116	93,382	37,962	0	233	55,187
North Dakota	397,493	193,105	170,232	0	17,398	743,432	105,996	0	637,436	0
Ohio	853,607	49,900	8,850	21,718	32,261	901,814	557,215	0	39,460	305,139
Oklahoma	13,775,049	577,123	839,797	12,080	944,569	14,259,480	7,039,245	3,451,540	3,666,629	102,066
Pennsylvania	776,212	141,521	14,880	27,986	107,004	853,595	470,958	0	28,715	353,922
[9]Texas	112,728,750	3,197,704	2,665,334	11,506	5,518,776	113,084,518	71,443,050	25,782,103	15,830,624	28,741
Utah	619,786	192,436	65,154	0	18,082	859,294	566,934	19,073	273,287	0
Virginia	35,557	3,375	1,125	0	2,536	37,521	37,521	0	0	0
West Virginia	1,561,737	131,686	27,960	23,524	183,977	1,560,930	1,262,271	0	66,033	232,626
Wyoming	3,235,932	261,026	113,798	796	154,119	3,457,433	2,551,332	221,829	665,257	19,015
[1]Miscellaneous	80,761	1,412	726	12,922	8,426	87,395	52,988	0	16,676	17,731
Total	237,774,569	11,118,319	8,998,993	179,733	11,502,359	246,569,255	168,473,371	44,294,040	32,119,876	1,681,968

[1] Includes Alabama, Arizona, Florida, Iowa, Maryland, Missouri and Nevada. [2] Excludes gas loss due to natural gas liquids recovery. [3] The net difference between gas stored in and gas withdrawn from underground storage reservoirs, inclusive of adjustments and native gas transferred from other reserve categories. [4] Net production equals gross withdrawals less gas injected into producing reservoirs. Changes in underground storage and gas loss due to natural gas liquids recovery are excluded. Fourth quarter production estimated in some instances. [5] Non-Associated Gas is free gas not in contact with crude oil in the reservoir; and free gas in contact with oil where the production of such gas is not significantly affected by the production of crude oil. [6] Associated Gas is free gas in contact with crude oil in the reservoir where the production of such gas is significantly affected by the production of crude oil. [7] Dissolved gas is gas in solution with crude oil in the reservoirs. [8] Gas held in underground reservoirs (including native and net injected gas) for storage purposes. [9] Includes off-shore reserves.

—The End



The Gulf Printing Company's recently completed addition added 93,000 square feet to office and printing areas. The new brown and buff tile building provides more than three acres of working space—the largest plant of its kind in the Southwest. By streamlining operations, the new plant makes it possible to speed up and improve service to Gulf Publishing subscribers.

$1 million investment in the future

. . . Expanding Gulf Publishing and Gulf Printing companies move into larger quarters . . .

PUBLISHING COMPANIES grow in direct proportion to the service they provide. And subscriber acceptance is the yardstick used to measure their success.

Since you, the subscriber, have been the key factor in Gulf Publishing's growth for 41 years, it is only proper that we share with you on these pages outstanding examples of the progress your acceptance has created. First of all, you have been directly responsible for the rapid circulation growth of WORLD OIL, PETROLEUM REFINER and PIPE LINE INDUSTRY magazines. During the past five years, Gulf's subscription lists have increased 52.8 percent —from 33,500 to more than 51,000— the largest circulation of any oil industry publisher.

This indication of reader acceptance has made it possible for our three industrial publications to increase total advertising by 1,317 pages during the same period—the biggest increase of any publisher serving the oil industry. Last year, Gulf Publishing advertising sales set a new record— 6,125 pages.

What's more, Gulf's bound equipment catalog files have greatly improved their service to those who buy and specify equipment and services. Since 1952, distribution of the composite catalogs serving drilling, production, pipe line and refining phases of the industry has increased 59 percent—from 17,130 to 27,212 recipients.

For these reasons—all examples of your faith in us—Gulf Publishing Company and Gulf Printing Company have made the following investments in the future:

Largest printing plant in the Southwest. More than 93,000 square feet of working area has just been added to the Gulf Printing plant in Houston at a cost of more than $950,000. The new, ultra-modern addition gives the plant a total of 135,000 square feet of office and printing facilities, the largest plant of its kind in the Southwest. More than 75,000 square feet of the new addition is air conditioned with a 400-ton central unit.

The added plant and office space has improved efficiency of publishing

See Pages 104 and 109

HOW TO BE A HERO AT INCOME TAX TIME

(And save yourself a few dollars, too!)

FIND YOUR STATE TAX HERE!

Based on tax rates as of October 1, 1957 (in cents per gallon).

	State	Federal	Total
Alabama	7	3	10
Arizona	5	3	8
Arkansas	6.5	3	9.5
California	6	3	9
Colorado	6	3	9
Connecticut	6	3	9
Delaware	5	3	8
Dist. of Col.	6	3	9
Florida	7	3	10
Georgia	6.5	3	9.5
Idaho	6	3	9
Illinois	5	3	8
Indiana*	6*	3	9
Iowa	6	3	9
Kansas	5	3	8
Kentucky	7	3	10
Louisiana	7	3	10
Maine	7	3	10
Maryland	6	3	9
Massachusetts*	5.5*	3	8.5
Michigan	6	3	9
Minnesota	5	3	8
Mississippi	7	3	10
Missouri	3	3	6
Montana*	7*	3	10
Nebraska*	7*	3	10
Nevada	6	3	9
New Hampshire*	6*	3	9
New Jersey	4	3	7
New Mexico	6	3	9
New York (State)	4	3	7
N. Carolina	7	3	10
N. Dakota	6	3	9
Ohio	5	3	8
Oklahoma*	7.5*	3	10.5
Oregon	6	3	9
Pennsylvania*	5*	3	8
Rhode Island	4	3	7
S. Carolina	7	3	10
S. Dakota*	6*	3	9
Tennessee	7	3	10
Texas	5	3	8
Utah*	6*	3	9
Vermont*	6.5*	3	9.5
Virginia	6	3	9
Washington	6.5	3	9.5
W. Virginia	6	3	9
Wisconsin	6	3	9
Wyoming	5	3	8
U. S. Average	5.8	3	8.8

*Changes during year: Ind.—tax was 4¢ before 3/15/57; Mass.—tax was 5¢ before 6/1/57; Mont.—rate will be 6¢ effective 1/16/58; Neb.—rate was 6¢ before 9/20/57; N. H.—tax was 5¢ before 9/1/57; Okla.—rate which was increased on 6/1/57 dropped back to 6.5¢ by 12/31/57; Penn.—tax was 6¢ before 6/1/57; S. D.—tax was 5¢ before 7/1/57; Utah, tax was 5¢ before 5/14/57; Vt.—tax was 5.5¢ before 7/15/57.

STEP #1 **Just tell your friends** that their state gasoline taxes can be deducted on their Federal Income Tax. (Other taxes, such as state and local sales taxes, may also be deducted but under a different formula.)

STEP #2 **It's so easy.** You'll find your state gasoline tax on the tax list on this page. Multiply that by the number of gallons purchased in 1957.

STEP #3 **Here's an example:** Friend "A" drove 10,000 miles last year and got 14 miles per gallon. That's 700 gallons of gasoline. Say your state tax rate is 6¢ a gallon. 700 times 6¢ is $42. So friend "A" gets a $42 deduction on his Federal Income Tax. You're a hero! And you've made a friend for your industry!

You can make even more friends for your industry when you tell people that they drive a bargain with today's gasoline. The price of gasoline itself has gone up only 17% in the last decade while taxes have gone sky high. For every dollar they spend on fuel itself, they spend an additional 40¢ in federal and state taxes. Mail the coupon below for more information about today's gasoline.

American Petroleum Institute, Dept. G
50 W. 50th Street, New York 20, N. Y.

I would like to obtain more information about today's gasoline quality, prices and taxes. Please send me your FREE booklets.

NAME_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

For more data on advertised products, use Readers' Service Cards, last page.

Until the new printing plant addition was opened earlier this year, the Gulf Publishing building had been the home of most of the printing facilities as well as publishing since 1928. The publishing building's interior has been completely remodeled in recent months. New improvements include relocation of the entrance, installation of new elevator, expansion of the library, plus addition of 11,200 square feet of badly needed space for the fast-growing publishing departments.

Gulf Publishing's oil library was recently expanded and reorganized. A popular source of oil industry information, the library is available to all who wish to make use of this company service. At left, WORLD OIL Editor Don Kliewer; center, WORLD OIL and PIPE LINE INDUSTRY Editorial Director Warren Baker; far right, PETROLEUM REFINER Editor George Gibbs.

operations, thus increasing subscriber service to the maximum. All of the printing departments—sales, printing of telephone directories, printing of publications and catalogs, plate making, composing room and art department—are now under one roof at the West Dallas Street address.

$250,000 worth of new equipment. To improve speed and efficiency in the printing of Gulf's industrial publications, two new two-color presses and a one-color press have been added to the 23 letterpresses and three offset presses already in use.

New bindery, composing room and offset plate making equipment have been installed. And there is ample room left for future expansion.

Expanded publishing facilities. By moving the printing equipment to the new plant, much needed office space was added for the fast-growing publishing staff. In fact, 11,200 extra square feet were provided, for a total of 24,000 square feet of office space, an increase of 85 percent.

The publishing company entrance has been moved and remodeled. A new elevator has been added. The mailing room has been moved to larger quarters, greatly improving its efficiency.

The circulation, book, advertising and editorial departments are now working under one roof—in completely remodeled offices.

New, Modern Library. Customer use of Gulf Publishing library has increased so rapidly in recent years it is now being reorganized and enlarged. A new index system has been set up to improve customer service. And a large number of new oil publications are constantly being added.

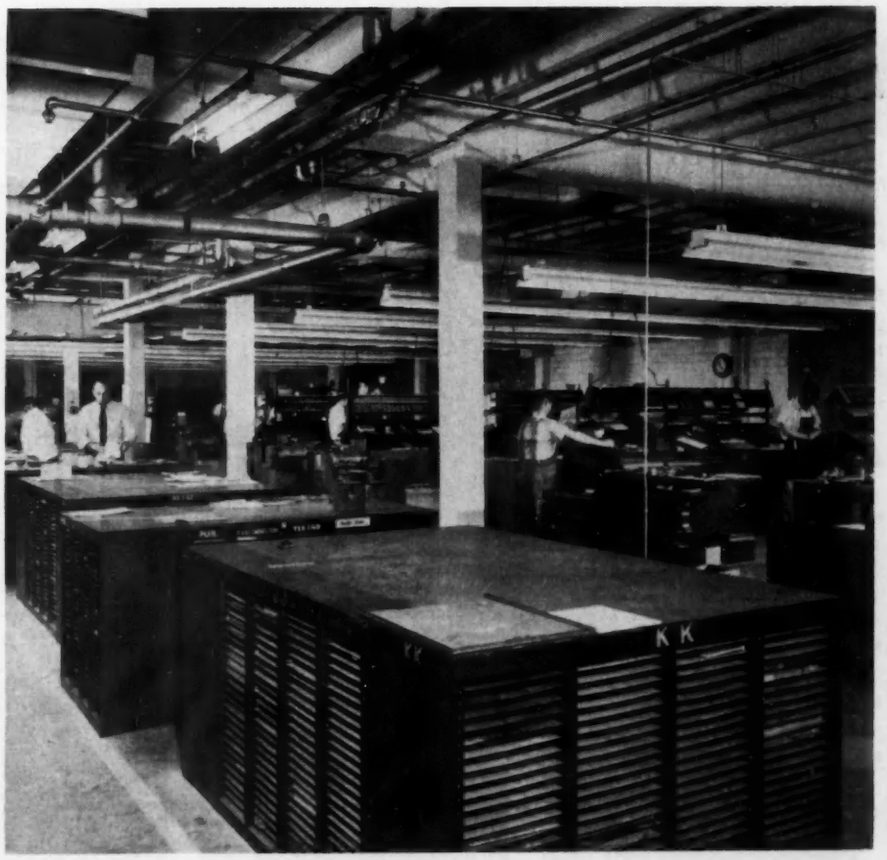
Gulf's research facilities are available to all, readers and advertisers alike, who are seeking information about the oil industry.

GPC's operations also include publishing of technical petroleum books and oil industry stock forms. Further expansion of these departments is being planned.

These are but a few of our investments and plans for the future. Thus, by improving subscriber service, we hope to increase your acceptance of Gulf publications.

That will be the key to our future growth. —**The End**

Each of the five two-color letterpresses shown above can print 16 multi-color WORLD OIL pages at once. In addition, the plant has 11 small automatic letterpresses, 4 large one-color letterpresses, 3 small two-color letterpresses, 2 large two-color offset presses, 2 small one-color offset presses, and another large two-color letterpress.



Enlarged composing room working area, plus the addition of new equipment, have made it possible to speed up the printing of Gulf's industrial publications. More than $235,000 worth of new equipment has been installed since last November.

Warren L. Baker, Editorial Director

Brighter U.S. outlook is in sight

Continued low refinery runs, coupled with drastic March and April production cuts, can cure excessive stocks, paving way for higher producing rates.

Big improvements in U. S. oil stocks during recent weeks, and definite indications that additional substantial reductions will occur in coming weeks, have materially brightened the industry's outlook.

Drastic March and April production cuts will go a long ways toward eliminating excessive inventories of crude oil. Cold weather in recent weeks boosted distillate fuel oil and kerosine consumption sufficiently to absorb excessive stocks of these products.

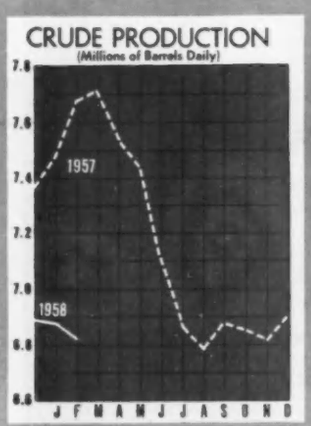
The industry, however, is still plagued with a number of economic problems. The coming of spring means the lowest oil consuming season of the year. This dictates the necessity of holding crude production, imports and refining operations to low levels until mid-year. In addition, gasoline and heavy fuel oil stocks are still excessive.

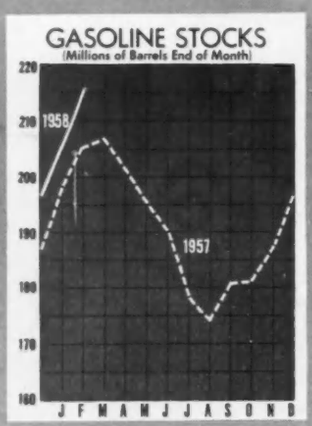
The immediate need is for U. S. refiners to hold crude runs to around 7½ million barrels daily.

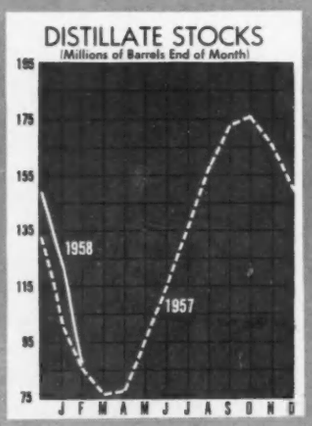
Gasoline stocks are quite excessive, at an all-time peak. Spring means higher gasoline consumption. If refinery runs are held to about 7½ million barrels per day, higher springtime gasoline consumption would lead to improvement in motor fuel inventories.

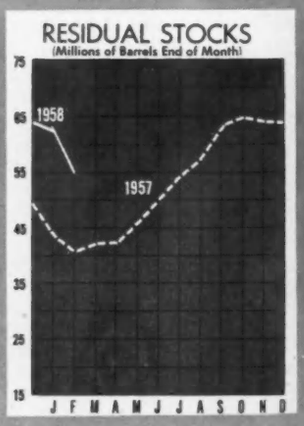
Residual fuel and other heavy oil stocks also are high. But spring means the road building season, and increased consumption of these products. The big national road building program might boost heavy oil consumption substantially in 1958. Therefore, low refining operations also should lead to desirable reductions in these stocks.

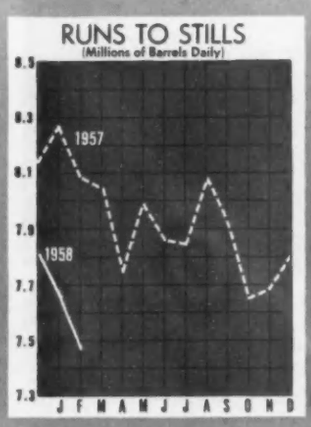
Petroleum Trends . . .

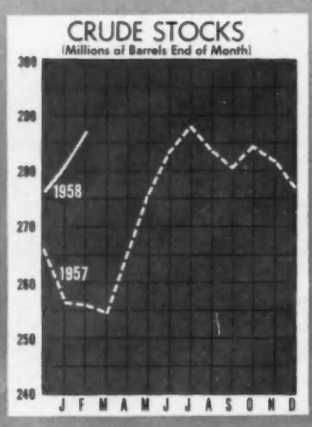


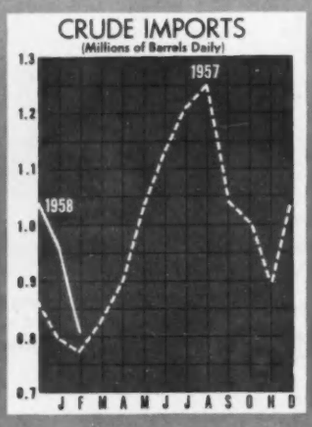


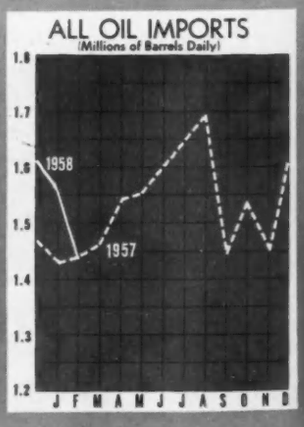












Stocks are in better shape than indicated by nation-wide figures. Virtually all the increase during the past year has been on the West Coast. Gasoline is the chief exception, and therefore must be given the industry's chief attention.

Crude inventories are 34 million barrels higher in the U. S. than a year ago, when they were at the lowest level in years due to five months of heavy emergency shipments to Western Europe during the Suez Canal crisis. Extremely low producing rates in March and April will reduce inventories outside of California by substantial amounts, bringing them much closer in line with the 265-million-barrel volume generally considered the maximum desirable level.

Distillate fuel oil inventories dropped to 81¾ million barrels by March 14 compared with 122⅓ million barrels at the beginning of February, because of cold weather causing a sharp gain in consumption. At this level they were only 2⅓ million barrels above year ago volumes, whereas on February 1 they had been 22 million barrels higher. Inventories outside of California were 2 million barrels smaller than a year ago on March 14, with West Coast stocks up 4⅓ million barrels.

U. S. stocks of residual fuel oil on March 14 were 19 million barrels larger than a year ago. But the increase outside of California was less than 1 million barrels.

Gasoline is the exception. National inventories were 11 million barrels above year ago volumes, and 9½ million barrels of this increase were outside of California.

Some relief from current low producing allowables is in sight after the middle of the year, especially if refining and imports rates are held to reasonable enough levels during the next several months to provide additional impovement in stocks.

The degree of increase will depend on consumption volumes and import rates. Demand in the last half of 1958 should be on a par with the corresponding period of 1957, unless general business activity takes a serious downward turn. If imports are curbed by something like 25 percent, this should permit a producing rate of around 6¾ million barrels daily, or considerably above very low March and April levels.

U. S. Crude Production by States

(THOUSANDS OF BARRELS)

STATE or DISTRICT	DAILY AVERAGE PRODUCTION Feb. 1958	Jan. 1958	Feb. 1957	% Diff. 1958-1957	TOTAL PRODUCTION FIRST TWO MONTHS 1958	1957	% Diff. 1958-1957
Alabama	15.8	15.3	11.8	+ 33.9	917	684	+ 34.1
Arkansas	83.5	83.1	89.1	— 6.3	4,914	5,102	— 3.7
California	894.5	921.0	939.8	— 4.8	53,599	55,415	— 3.3
Colorado	140.6	140.1	158.8	— 11.5	8,281	9,361	— 11.5
Florida	1.3	1.3	1.3	.....	75	74	+ 1.4
Illinois	232.8	235.6	219.5	+ 6.1	13,820	13,156	+ 5.0
Indiana	31.0	30.8	37.0	— 16.2	1,824	2,154	— 15.3
Kansas	332.0	335.5	335.2	— 1.0	19,696	19,726	— 0.2
Kentucky	40.7	41.5	47.0	— 13.4	2,425	2,753	— 12.0
Louisiana	849.7	846.3	1,025.8	— 17.1	50,026	59,629	— 16.1
North Louisiana	111.9	114.6	142.2	— 21.3	6,686	8,308	— 19.5
South Louisiana	737.8	731.7	883.6	— 16.5	43,340	51,326	— 15.6
Michigan	25.7	25.9	28.8	— 10.8	1,525	1,692	— 9.9
Mississippi	103.9	105.1	117.3	— 11.4	6,167	6,772	— 8.9
Missouri—Tennessee	.3	.3	.2	+ 50.0	16	10	+ 60.0
Montana	75.2	74.7	70.9	+ 6.1	4,423	4,107	+ 7.7
Nebraska	53.7	54.6	50.5	+ 6.3	3,197	2,875	+ 11.2
Nevada	.1	.2	0.1	.....	9	6	+ 50.0
New Mexico	264.6	268.2	266.6	— 0.8	15,724	15,401	+ 2.1
Southeast New Mexico	257.9	262.3	259.4	— 0.6	15,352	15,059	+ 1.9
Northwest New Mexico	6.7	5.9	7.2	— 7.0	372	342	+ 8.7
New York	6.3	6.9	7.5	— 16.0	389	429	— 9.3
North Dakota	34.8	37.1	39.8	— 12.6	2,124	2,410	— 11.9
Ohio	14.9	16.3	13.9	+ 7.2	920	794	+ 15.9
Oklahoma	563.2	568.6	643.3	— 12.5	33,396	37,038	— 9.8
Pennsylvania	17.8	19.6	23.2	— 23.3	1,105	1,346	— 17.9
South Dakota	.2	.2	.1	+100.0	12	5	+140.0
Texas	2,707.0	2,727.5	3,226.3	— 16.1	160,349	187,066	— 14.3
Dist. 1 South Central	48.3	46.7	56.5	— 14.5	2,800	3,318	— 15.6
Dist. 2 Middle Gulf	130.2	128.8	161.0	— 19.1	7,638	9,299	— 17.8
Dist. 3 Upper Gulf	400.5	412.7	460.0	— 12.9	24,005	27,117	— 11.5
Dist. 4 Lower Gulf	205.0	203.9	244.6	— 16.2	12,050	14,193	— 15.0
Dist. 5 East Central	35.2	32.3	42.5	— 17.2	1,987	2,422	— 18.0
Dist. 6 Northeast	290.8	284.7	358.8	— 19.0	16,970	20,693	— 18.0
Dist. 7-B North Central	147.6	146.0	165.1	— 10.6	8,659	9,642	— 10.2
Dist. 7-C West Central	145.7	151.2	174.7	— 16.6	8,767	10,212	— 14.2
Dist. 8 West	995.0	1,017.8	1,157.4	— 14.0	59,412	67,866	— 12.5
Dist. 9 North	201.1	198.7	212.8	— 5.5	11,792	12,447	— 5.3
Dist. 10 Panhandle	107.6	104.7	98.3	+ 9.5	6,259	5,902	+ 6.0
Utah	16.1	15.2	10.3	+ 56.3	920	622	+ 47.9
Virginia	.....	.....	.....	.....	1	1	.....
Washington	.....	.....	.....	.....	1	.....	.....
West Virginia	5.2	5.8	6.0	— 13.3	326	349	— 6.6
Wyoming	309.9	306.1	312.0	— 0.7	18,169	17,999	+ 0.9
TOTAL UNITED STATES	6,820.8	6,882.8	7,682.1	— 11.2	404,350	446,979	— 9.5

Source: Bureau of Mines and API. Texas Districts from API and do not necessarily agree with State totals.

U. S. Crude Oil and Refined Product Trends

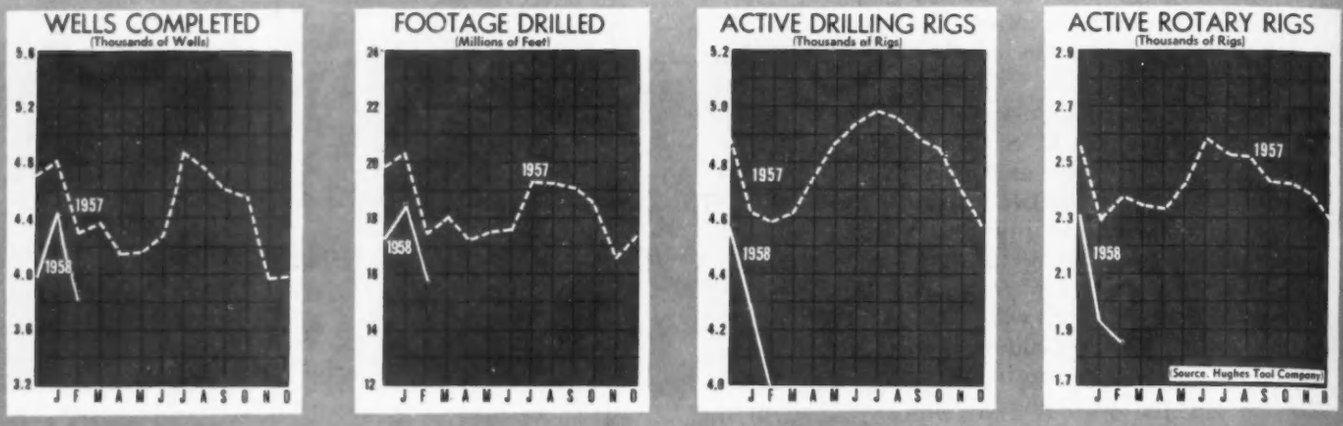
(THOUSANDS OF BARRELS)

MONTH	CRUDE OIL Production Daily	Runs to Stills Daily	Stocks End of Month	GASOLINE Production Daily	Stocks End of Month	DISTILLATE FUEL Production Daily	Stocks End of Month	RESIDUAL FUEL Production Daily	Stocks End of Month	DAILY IMPORTS Crude Oil	Total Oils
1956:											
February	7,208	8,047	259,504	3,854	196,092	1,918	71,335	1,286	35,673	878	1,472
March	7,278	7,914	265,683	3,829	199,698	1,808	60,846	1,213	32,984	934	1,428
April	7,146	7,487	277,121	3,646	193,299	1,713	63,571	1,130	32,740	815	1,305
May	7,064	7,896	277,497	3,859	186,673	1,667	75,928	1,149	36,607	938	1,416
June	7,100	8,071	274,491	3,976	177,076	1,755	93,758	1,098	39,073	987	1,426
July	7,090	8,014	277,008	3,975	176,536	1,767	115,787	1,066	43,958	1,084	1,463
August	7,195	7,995	279,944	4,037	172,939	1,839	137,905	1,091	46,617	1,001	1,399
September	7,054	8,024	278,791	3,991	177,974	1,845	150,411	1,062	47,342	1,043	1,452
October	6,966	7,608	286,560	3,773	172,798	1,772	158,871	1,082	48,400	1,004	1,541
November	7,139	8,031	275,995	3,913	174,808	1,841	151,517	1,182	44,590	871	1,362
December	7,377	8,141	266,014	4,039	187,271	1,981	133,981	1,288	44,491	873	1,471
1957:											
January	7,480	8,274	256,669	3,991	197,702	2,118	100,572	1,322	38,403	805	1,421
February	7,682	8,088	256,344	3,864	205,270	2,035	85,105	1,270	36,201	780	1,430
March	7,717	8,047	254,911	3,826	206,716	1,861	76,245	1,205	37,371	836	1,464
April	7,541	7,740	265,796	3,770	201,407	1,764	78,743	1,132	37,429	906	1,542
May	7,442	7,992	275,963	3,900	195,094	1,789	98,135	1,103	41,125	1,042	1,558
June	7,107	7,867	284,312	3,984	190,063	1,773	117,364	1,101	45,572	1,147	1,606
July	6,873	7,852	288,241	3,887	177,868	1,750	138,359	1,090	49,621	1,220	1,654
August	6,786	8,092	283,388	4,122	174,031	1,806	159,124	1,089	52,645	1,257	1,695
September	6,887	7,920	280,469	4,099	180,688	1,772	173,269	1,100	58,727	1,042	1,445
October	6,860	7,650	284,517	3,939	180,902	1,705	176,388	1,052	60,025	1,022	1,532
November	6,824	7,692	281,769	3,901	187,141	1,734	166,763	1,069	59,622	902	1,455
December	6,929	7,816	281,813	4,001	196,776	1,886	149,449	1,142	59,959	1,130	1,909
1958:											
January	6,883	7,661	280,601	3,832	205,057	1,855	122,325	1,067	57,520	955	1,550
February	6,821	7,447	287,780	3,756	215,222	1,721	87,978	1,086	54,293	801	1,443
Week Ended:											
3-15-58	6,257	7,479	*286,085	3,664	216,525	1,699	81,853	1,023	55,061	905	1,533
3-16-57	7,652	8,098	*251,993	3,726	205,589	1,949	79,599	1,218	36,283	908	1,697

* Previous week's stocks.

Source: Data for last two months from API; prior monthly data from Bureau of Mines.

Drilling Activities . . .



Drilling activity drops again; daily completions average 136

U. S. DRILLING activity underwent another sharp reduction during February. An average of only 136 wells was completed daily in February, 1958, in contrast with 143 during January, 1958, and 155 during both January and February, 1957.

A total of 8,259 wells and 34,374,444 feet of hole was drilled during the first two months of 1958. This was in contrast with 9,111 wells and 37,782,916 feet during the same months of 1957. The decline amounts to 9.4 percent for both wells and footage.

Well completions during February, 1958, totaled 3,810 wells with footage totaling 15,725,628 feet. This was a decrease of approximately 450 wells from the 4,262 wells drilled in February a year ago.

The reduction raises doubts whether the forecast of 50,000 wells and 207.8 million feet of hole during 1958 will be achieved. A sizable increase in drilling activity later in the year will be necessary if 50,000 wells and more than 200 million feet of hole are to be drilled in 1958.

The outlook is not improved by another sharp drop in active drilling rigs. Only 3,970 drilling rigs were in operation at the end of February, a decrease of 320 from the end of January, and a decrease of 612 rigs from the end of February, 1957. Rigs operating at the end of February, 1958, were the lowest since May, 1944.

The decrease in rigs operating presages a further decline in well completion and footage rates. While improved stocks and prospective gains in producing rates during the last half of the year should lead to some improvement in drilling activity, the increase may not be sufficient to result in the completion of 50,000 wells this year.

Texas suffered the greatest decline for the two months with 19.5 percent fewer wells than were drilled a year ago. This represented 763 fewer wells with 2.8 million less footage. Kansas followed with a decrease of 236 wells.

Oklahoma held the lead in increased activity, completing a total of 641 wells in February. This was an increase of 144 wells over January and the first time the total count has passed the 600 mark since January, 1957, when 609 wells were drilled. There was a monthly average of 472 wells drilled in Oklahoma during 1957.

Wildcat drilling took a sharp drop during the two month period with 7.5 percent fewer total discovery wells and 15.8 percent less dry holes than were accounted for in the first two months of last year. A slight increase is noted in actual discoveries during February with 111 producing wells as against 98 for January but there were 157 fewer total wells drilled during the month.

Western Canada lost quite a bit of gain picked up in January with its 274 wells completed as against 156 for February but the increase in rigs going into operation should see this lead regained within a short time. At the end of the month, there were 248 active rigs in the area, an increase of 52 over the total 196 rigs accounted for at the end of January.

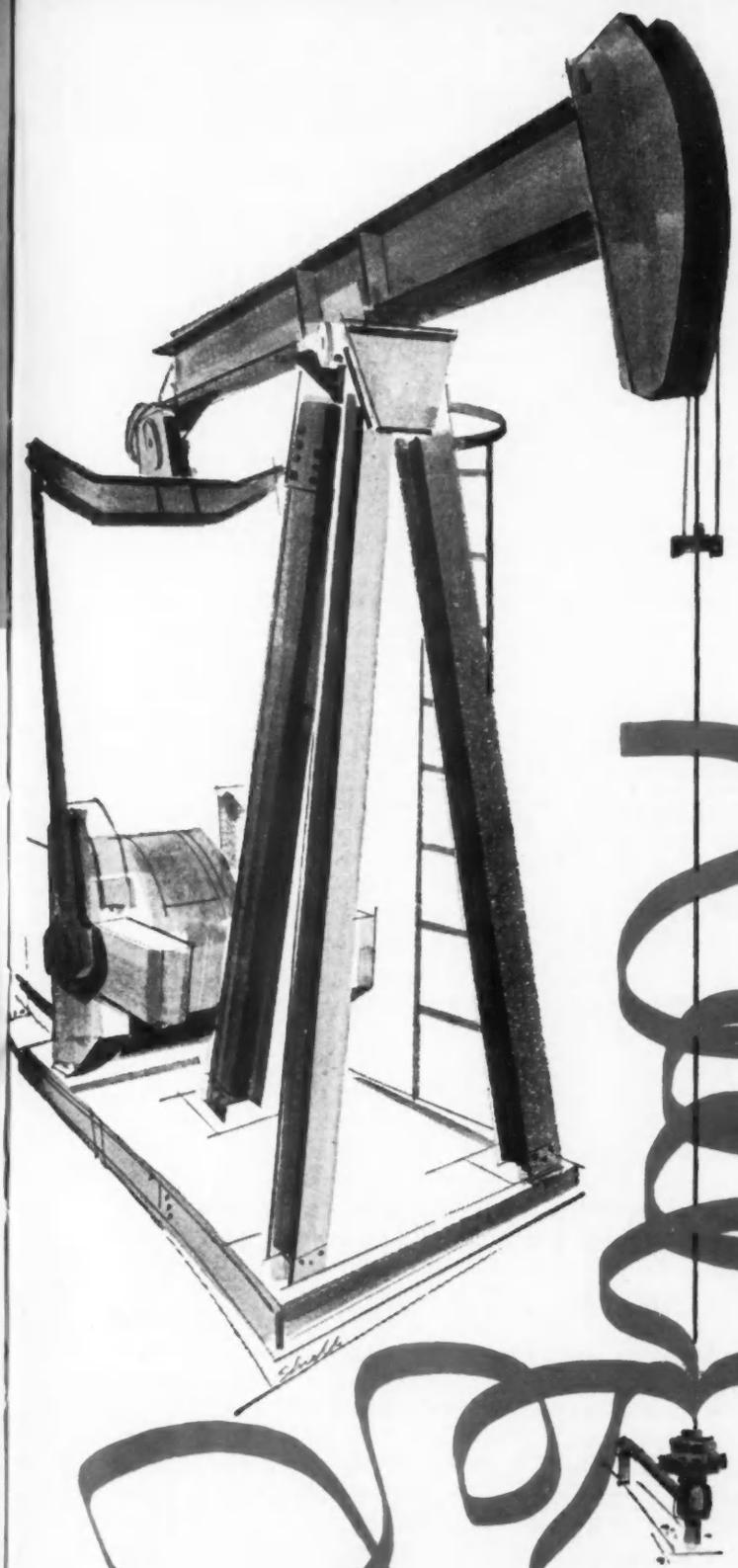
Summary of U. S. Drilling Activity

ITEM	Feb. 1958	Jan. 1958	TWO MONTHS January-February 1958	1957	% Diff.
New Wells Completed:					
Oil	1,927	2,241	4,168	4,991	—16.5
Distillate	62	61	123	93	+32.3
Gas	322	368	690	581	+18.8
Service	142	140	282	162	+74.1
Dry	1,357	1,639	2,996	3,284	— 8.8
Total Wells	3,810	4,449	8,259	9,111	— 9.4
Footage Drilled (Mln. of Feet)	15.7	18.5	34.2	37.8	— 9.5

Summary of U. S. Wildcat Drilling

ITEM	Feb. 1958	Jan. 1958	TWO MONTHS January-February 1958	1957	% Diff.
New Field Discoveries:					
Oil	74	67	141	161	—12.4
Distillate	13	3	16	24	—33.3
Gas	24	28	52	41	+26.8
Total Discoveries	111	98	209	226	— 7.5
Dry Wildcats	633	803	1,436	1,706	—15.8
Total Wildcats	744	901	1,645	1,932	—14.9
Percent Productive	14.9	10.9	12.7	11.7	.....
Percent Dry	85.1	89.1	87.3	88.3	.....

Details on Page 114



are you pumping red tape?

If you are there's no quick, easy solution to your problem. But an answer must be found. The red tape of oil operation can choke production as surely as a well that is sanding up. These higher operation costs can cut your profit to the point that you are working only for your creditors.

Although you have no control over your sales price, you can control your costs. Working with your legal and tax counsel, The Commerce can analyze your costs, find where economies can be effected, thereby increasing the profitableness of your operation by helping you to cut your costs. Your income goes up when you stop pumping red tape.

Facilities of The National Bank of Commerce Oil Loan Department are available in Wyoming, Nebraska, Colorado, New Mexico, Texas, Louisiana, and Mississippi.

E. O. Buck, vice president, Oil Loan Department

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

THE NATIONAL BANK OF

COMMERCE

OF HOUSTON

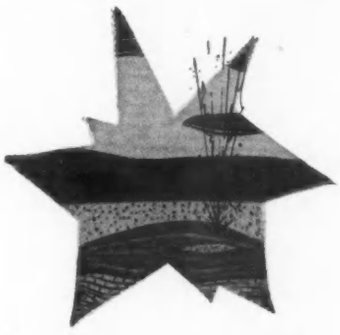
Gulf Building, Houston, Texas

U. S. Drilling Activity in February and First Two Months, 1958—1957

STATE or DISTRICT	TOTAL NEW WELLS COMPLETED AND FOOTAGE DRILLED — DETAILS FOR FEBRUARY, 1958					TOTAL NEW WELLS			Total Footage Feb. 1958	DETAILS FOR JANUARY-FEBRUARY					WILDCAT DRILLING IN FEBRUARY AND FIRST TWO MONTHS, 1958-1957 — DETAILS FOR FEB., 1958					DETAILS FOR JANUARY-FEBRUARY					DRILLING RIGS IN OPERATION (Rigging-Up, Drilling, Temp. Shut-Down)		
										NEW WELLS			FOOTAGE									TOTAL WILDCATS					
	Oil	Dist.	Gas	Dry	Service Wells	Feb. 1958	Jan. 1958	Feb. 1957		1958	1957	Percent Diff.	1958	1957	Oil	Dist.	Gas	Dry	Total Wildcats	Oil	Dist.	Gas	Dry	1958	1957	Feb. 28, 1958	Jan. 31, 1958	Feb. 28, 1957
Alabama	4	....	....	2	....	6	4	15	59,886	10	17	— 41.2	99,609	132,923	....	....	....	2	2	....	....	....	4	4	7	13	11	24
Arizona	....	....	....	....	....	....	1	....	....	1	....	....	590	....	....	....	....	....	....	....	....	....	1	1	....	7	6	1
Arkansas	20	....	....	21	....	41	69	67	134,211	110	182	— 39.6	343,461	500,189	2	....	....	9	11	2	....	1	18	21	18	49	41	67
California	100	....	1	27	....	128	181	143	554,831	309	352	— 12.2	1,329,280	1,605,994	....	....	....	16	16	1	....	....	40	41	63	142	160	179
Colorado	12	....	7	43	....	62	67	74	333,912	129	160	— 19.4	671,462	835,277	2	....	1	24	27	8	....	3	53	64	96	43	54	46
Florida	....	....	....	....	....	....	....	1	....	....	2	—100.0	....	16,240	....	....	....	....	....	....	....	....	....	2	2	2	1	1
Georgia	....	....	....	....	....	....	....	1	....	....	1	—100.0	....	7,425	....	....	....	....	....	....	....	....	....	1	....	....	....	....
Idaho	....	....	....	....	....	....	....	....	....	....	1	—100.0	....	3,947	....	....	....	....	....	....	....	....	....	1	....	....	....	....
Illinois	71	....	5	72	....	148	218	166	313,475	366	382	— 4.2	803,610	865,401	....	....	....	32	32	1	....	....	85	86	102	239	240	254
Indiana	17	....	4	51	2	74	74	39	114,786	148	111	+ 33.3	274,468	177,392	1	....	1	22	24	1	....	....	39	41	30	96	105	102
Kansas	130	....	20	131	10	291	296	365	985,197	587	723	— 18.8	2,041,843	2,564,753	11	....	1	57	69	14	....	2	120	136	148	441	500	480
Kentucky	30	....	11	50	1	92	117	87	135,663	209	204	+ 2.5	317,256	335,788	....	....	....	4	4	1	....	1	12	14	8	89	84	103
Louisiana	139	19	23	76	....	257	317	269	2,118,720	574	560	+ 2.5	4,672,547	4,820,702	5	3	....	23	31	9	4	1	57	71	96	339	366	423
North Louisiana	54	....	15	20	....	89	107	97	308,359	196	237	— 17.3	739,594	849,281	1	....	....	3	4	2	....	....	7	9	28	72	77	77
South Louisiana	85	19	8	56	....	168	210	172	1,810,361	378	323	+ 17.0	3,932,953	3,971,421	4	3	....	20	27	7	4	1	50	62	68	267	289	346
*Gulf of Nexico	33	3	1	12	....	49	45	54	461,738	94	93	+ 1.1	882,254	878,057	1	1	....	1	3	1	1	....	4	6	15	52	62	94
Maryland	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Michigan	12	....	1	13	....	26	24	28	71,170	50	63	— 20.6	143,239	199,257	....	....	....	9	9	....	....	1	16	17	27	56	55	62
Mississippi	7	....	1	16	....	24	42	30	206,053	66	57	+ 15.8	558,472	408,893	1	....	....	10	11	3	....	....	29	32	28	36	44	28
Missouri	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....
Montana	7	....	1	11	....	19	38	12	100,894	57	49	+ 16.3	327,661	281,038	....	....	1	8	9	3	....	3	22	28	15	32	36	38
Nebraska	11	....	....	35	....	46	47	49	280,227	93	134	— 30.6	570,069	798,415	2	....	....	18	20	6	....	....	34	40	70	26	22	37
Nevada	....	....	....	....	....	....	....	....	....	....	1	—100.0	....	3,386	....	....	....	....	....	....	....	....	....	1	1	1	1	3
New Mexico	82	1	26	28	2	139	254	195	718,848	393	416	— 5.5	1,870,409	1,863,190	4	....	2	15	21	7	....	10	45	62	61	149	170	155
New York	21	....	1	2	24	48	48	42	73,800	96	75	+ 28.0	147,600	128,500	....	....	....	....	....	....	....	....	....	....	....	47	44	50
North Dakota	26	....	....	17	....	43	31	25	320,131	74	51	+ 45.1	518,550	339,005	4	....	....	11	15	6	....	....	15	21	22	38	45	22
Ohio	25	....	22	11	....	58	88	78	160,563	146	153	— 4.6	394,519	364,651	....	....	....	....	....	....	....	....	2	2	3	216	226	228
Oklahoma	336	8	40	207	50	641	497	522	2,011,734	1,138	1,131	+ 0.6	3,783,918	3,878,479	6	1	4	52	63	10	1	8	99	118	123	512	610	577
Oregon	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....
Pennsylvania	37	....	24	7	34	102	96	69	256,772	198	143	+ 38.5	462,602	394,881	....	....	1	....	1	....	....	2	....	2	9	102	108	156
South Dakota	....	....	....	....	....	....	3	4	....	3	6	— 50.0	16,991	25,314	....	....	....	....	....	....	....	....	3	3	6	....	....	6
Texas	766	34	93	492	19	1,404	1,748	1,874	6,086,781	3,152	3,915	— 19.5	13,541,839	16,376,084	35	9	10	301	355	66	11	16	680	773	944	1,014	1,050	1,261
Dist. 1 South Central	40	1	1	41	....	83	79	101	184,668	162	239	— 32.2	412,252	632,749	....	....	....	26	26	3	....	....	51	54	71	34	32	48
Dist. 2 Middle Gulf	11	6	5	15	....	37	48	56	229,816	85	123	— 30.9	532,941	785,539	....	1	2	9	12	2	2	3	17	24	42	40	38	39
Dist. 3 Upper Gulf	47	5	5	35	....	92	130	134	622,084	222	313	— 29.1	1,469,348	2,167,796	....	....	....	1	21	1	....	2	49	52	92	77	94	133
*Gulf of Mexico	....	....	1	1	....	2	....	....	15,685	2	4	— 50.0	15,685	31,433	....	....	....	1	1	....	....	1	....	1	3	1	1	1
Dist. 4 Lower Gulf-S.W.	27	8	9	48	....	92	95	97	456,363	187	223	— 16.2	999,567	1,165,212	1	4	1	32	38	4	4	2	72	82	75	50	57	68
*Gulf of Mexico	....	....	....	....	....	....	....	2	....	....	3	—100.0	....	27,571	....	....	....	....	....	....	....	....	....	....	....	1	1	4
Dist. 5 East Central	2	....	....	8	....	10	25	13	41,650	35	29	+ 20.7	135,554	161,346	....	....	....	5	5	....	....	....	20	20	21	5	5	7
Dist. 6 Northeast	41	4	5	28	....	78	98	85	405,377	176	189	— 6.9	924,365	1,044,816	....	....	1	18	19	2	....	1	39	42	43	57	46	72
Dist. 7-B North Central	79	1	8	97	1	186	217	200	606,654	403	461	— 12.6	1,315,181	1,535,504	10	1	1	66	78	14	1	1	133	149	160	105	97	117
Dist. 7-C West Central	51	....	1	23	1	76	91	136	414,492	167	258	— 35.3	863,452	1,184,657	5	....	....	17	22	7	....	....	43	50	75	65	70	90
Dist. 8 West	260	....	9	51	3	323	397	487	1,703,091	720	874	— 17.6	3,558,854	4,303,114	9	....	2	33	44	15	....	2	81	98	96	329	314	326
Dist. 9 North	157	7	18	132	14	328	448	465	980,513	776	972	— 20.2	2,296,665	2,465,487	7	1	1	66	75	14	2	2	151	169	248	157	184	238
Dist. 10 Panhandle	51	2	32	14	....	99	120	100	442,073	219	234	— 6.4	1,033,660	929,864	3	2	1	8	14	4	2	3	24	33	21	95	113	123
Utah	32	....	....	9	....	41	40	7	239,185	81	16	+406.3	467,740	93,838	....	....	....	5	5	....	....	....	12	12	6	53	60	36
Washington	....	....	....	2	....	2	1	....	10,157	3	....	....	18,557	....	....	....	....	1	1	....	....	....	2	2	....	....	....	....
West Virginia	10	....	40	12	....	62	69	37	188,016	131	90	+ 45.5	368,018	261,641	....	....	2	....	2	....	....	2	....	2	6	167	173	177
Wyoming	32	....	2	22	....	56	79	63	250,616	135	116	+ 16.4	570,134	500,313	1	....	1	14	16	3	....	1	48	52	38	61	77	65
Total United States	1,927	62	322	1,357	142	3,810	4,449	4,262	15,725,628	8,259	9,111	— 9.4	34,274,444	37,782,916	74	13	24	633	744	141	16	52	1,436	1,645	1,912	3,970	4,290	4,582
Total Western Canada	95	....	4	56	1	156	274	249	839,646	430	473	— 9.1	2,598,966	2,157,247	....	....	....	....	....	....	....	....	.....	.....	.....	248	196	232

* Gulf of Mexico wells are included in their respective district totals.

Exploration Section



PROGRESS leads to challenges which, in turn, lead to continuing development. This cycle is responsible for the level of achievement which the field of exploration has attained and for the vital role it plays in the search for oil. WORLD OIL has devoted this entire section to developments in this field. Technological advances are discussed on the following pages; challenges facing exploration are pinpointed in the editorial below.

By Graham B. Moody, Past President, The American Association of Petroleum Geologists, Berkeley, Calif.

ENERGY REQUIREMENTS have been rising during the past years and will continue to increase in the future. Oil and gas currently supply about two-thirds of our total energy needs and, according to present indications, will provide about the same proportion for at least the next 10 years. This presents a challenge to the exploratory fraternity, which is accustomed to being challenged.

Near the turn of this century the geologist worked alone in the scientific search for oil. He had no help from other sciences and little significant information from the logs of wells that were drilled. Now many sciences are involved in the hunt for oil, and each one is important in its own right. It is true, however, that the interpretation of seismic surveys, paleontological studies, electric and other logs, core analyses and numerous other aids to exploratory effort is based fundamentally on observations made of rocks in the field. Surface geology is, therefore, still of paramount importance in looking for oil; it furnishes the yardsticks for subsurface interpretations.

The term "geologist" in the following comments is intended as a generic term to cover all of those actively engaged in the scientific search for oil—field geologists, subsurface geologists, paleontologists, geophysicists, research men and others.

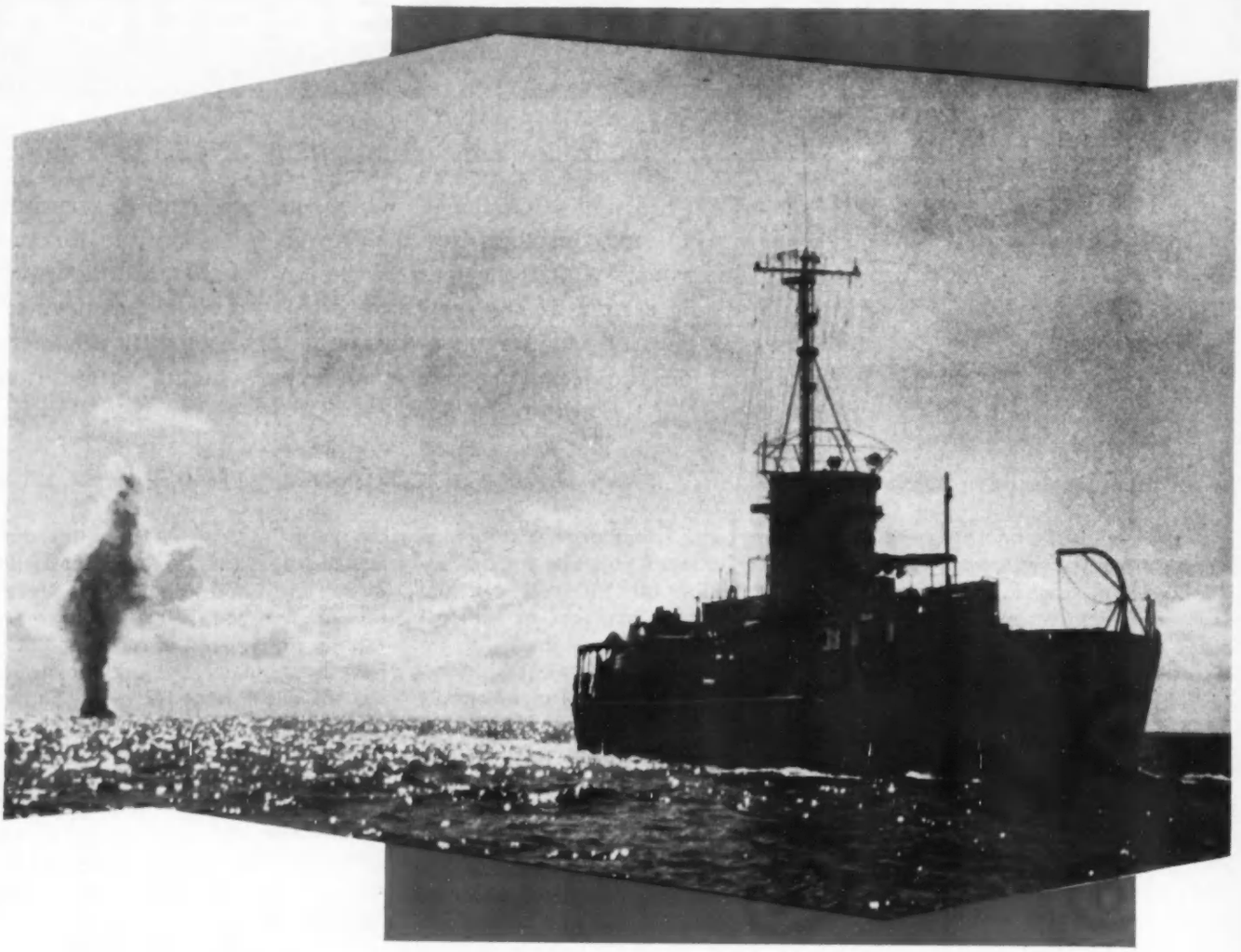
Petroleum is the life-blood of any company engaged in the business of producing and marketing that commodity. Pipe lines, refineries and sales outlets are of no value unless the company has a continuous supply of crude. It must find new sources to replace its production or it becomes a liquidating concern. The key man in any such company, therefore, is the one charged with the responsibility of finding oil. You may call him chief geologist, manager of exploration, vice president in charge of exploration or president, but, whatever his title, he should be fundamentally a finder of oil.

It is axiomatic that the geologist has sound basic training in the numerous sciences involved in the search for oil. It is not enough, however, that he has training in these sciences. In addition he is completely absorbed in his pursuit of oil; and he has confidence in his ability to look for likely oil deposits. Hence, he is truly optimistic about the probability of finding oil. He has a lively imagination tempered by experience and judgments, and he has the courage of his convictions. One other outstanding attribute that makes him an efficient finder of oil is that he can use numerous, apparently unrelated bits of data derived from the efforts of various scientists working on exploration and fit them together to form a comprehensive definite picture indicating where to drill. There are many who can solve individual problems involved in an exploratory project, but those that can piece together all data into a final conclusive decision are less in number. The geologist who does this is practicing both the art and the science of exploration. He is the indispensable man in exploration.

It has been said that we are experiencing a business recession. There are many news items about the difficulties facing the oil industry because of a general lowering of business activity. It is interesting, but slightly confusing, to read one account that bewails the excess producing capacity in the U. S. and another one, alongside the first one, fearing that we are rapidly running out of reserves. There have been many ups and downs in the oil business in the past. Supply and demand have not always been in balance; price adjustments have been necessary. Such short term fluctuations in the economic picture should not alter the course of exploration. More oil is always needed and the way to find it is through exploration.

Some companies already have "retrenched" by laying off geologists whereas others simply are not adding any new men. An oil company that is in the business of finding and producing oil as a permanent activity has an excellent opportunity to add to its reserves during a business recession. That is the time to add to the exploratory force, to analyze all the forgotten data in its files, to develop exploratory projects and to acquire prospective acreage in order to be prepared for intensive exploratory drilling when business improves. It may be possible for an oil company to protect its resources by laying off non-vital employes but certainly not by dismissing those who are finding the oil for them.

Exploration has successfully met all challenges encountered in the past. Despite continuously rising demand and production, our proven reserves are steadily growing greater. There is plenty of oil left for the finding, and if found, to meet our requirements for years to come. Let's apply our talents to the job and find that oil! **—The End**



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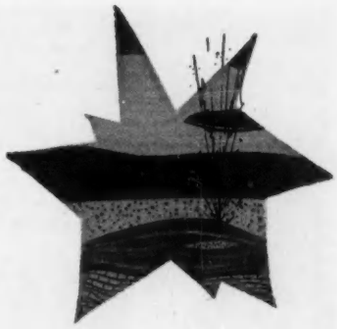


Let's take a second look at magnetic tape

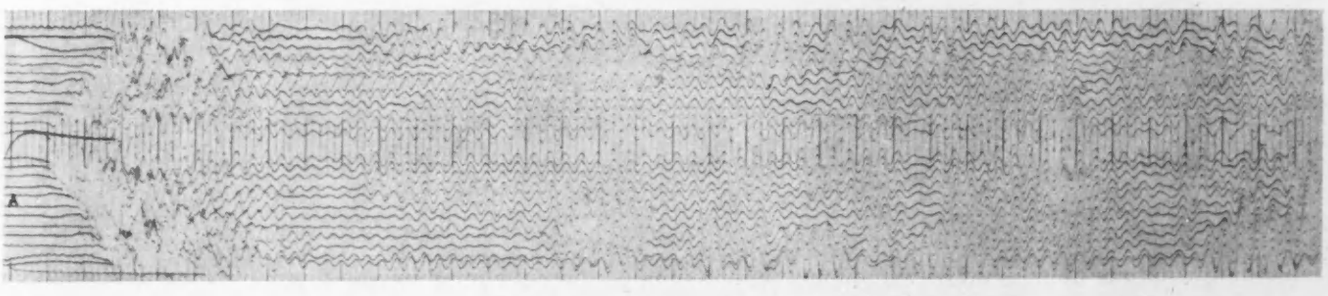
Here is an evaluation of its use, systems presently employed and the evolution of standardization to its present status.

By C. F. Wendenburg, Superintendent, Geophysical Operations Unit,
and **John M. Sharpe,** Geophysical Laboratory Supervisor
Sohio Petroleum Company, Houston

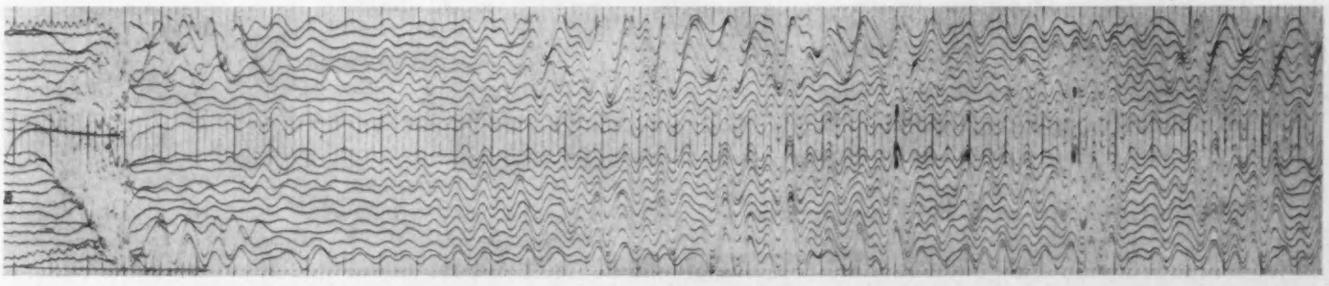
OIL COMPANIES and geophysical contractors who have been recording field data on magnetic tape for several years are taking a second look at the economics of their investments. In some areas, data have not been improved sufficiently to justify the use of tape; however, data have been upgraded in other areas because tape was used.

Manufacturers have been cooperative in an attempt to solve individual problems in designing processing equipment to obtain better seismic data. Many companies have developed their own tape systems and there are many different types of field tape recorders and playback systems now in use. Most companies evaluated the various systems, standardized in general on one particular system and patterned their facilities for use primarily with this equipment. It appears that standardization of field recorders in the near future will be impossible. Playback systems need only be adapted to accept the various field tape dimensions; therefore, standardization of recorders would not be necessaary.

Cost of field tape recording equipment is minor compared with total cost of present day field operations. Where crews are operating in good data areas, perhaps this increased expenditure is unnecessary. But for the

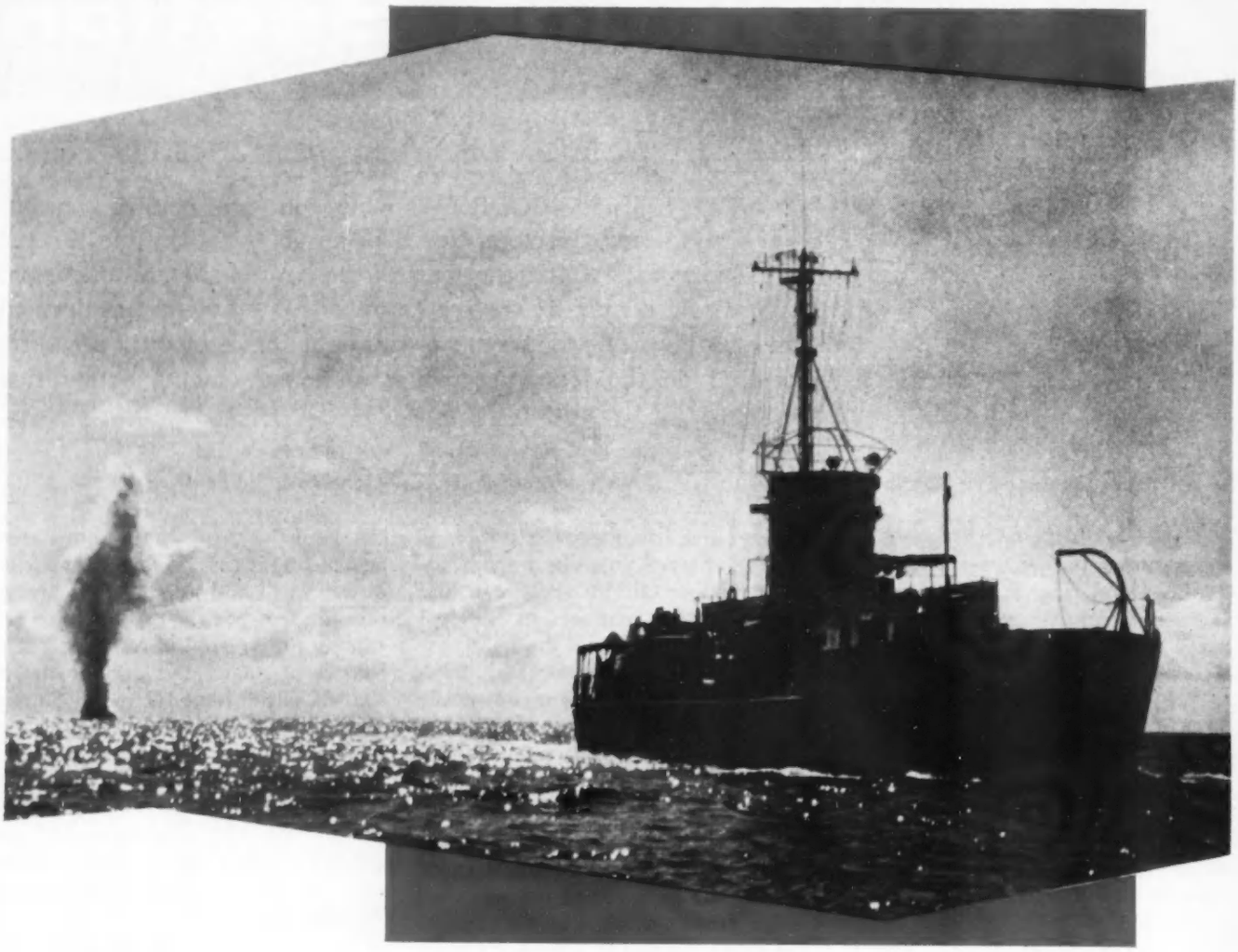


RECORD A



RECORD B

FIGURE 1—An example of two seismograms processed from the same field tape. Record A shows the unwanted noise interfering with the desired signal. Record B shows the improvement in data obtainable due to specialized playback processing techniques. Note that reflection line-ups easily seen in Record B are masked by interference in Record A.



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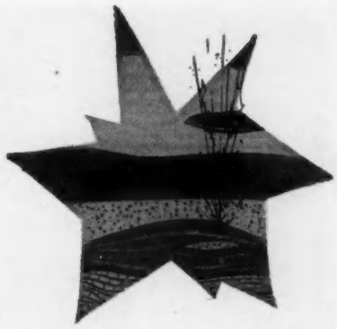

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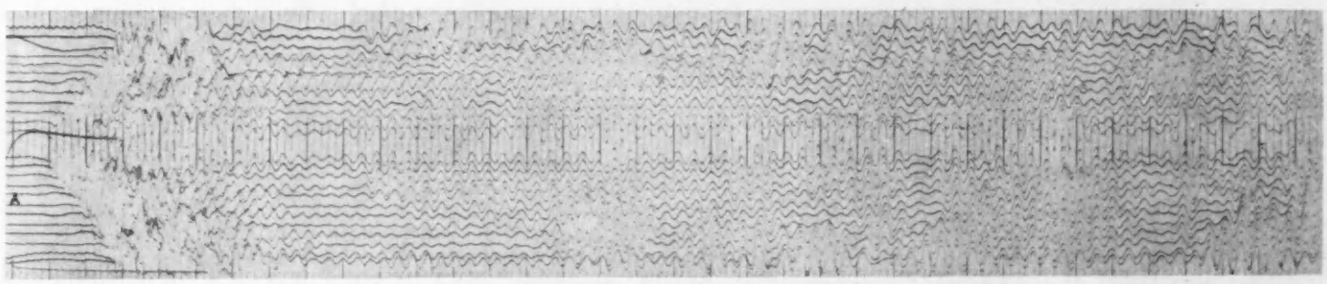
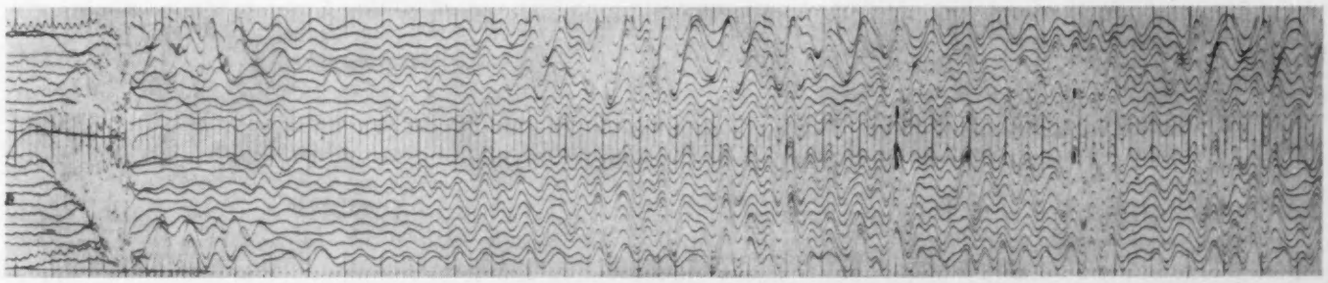


RECORD A



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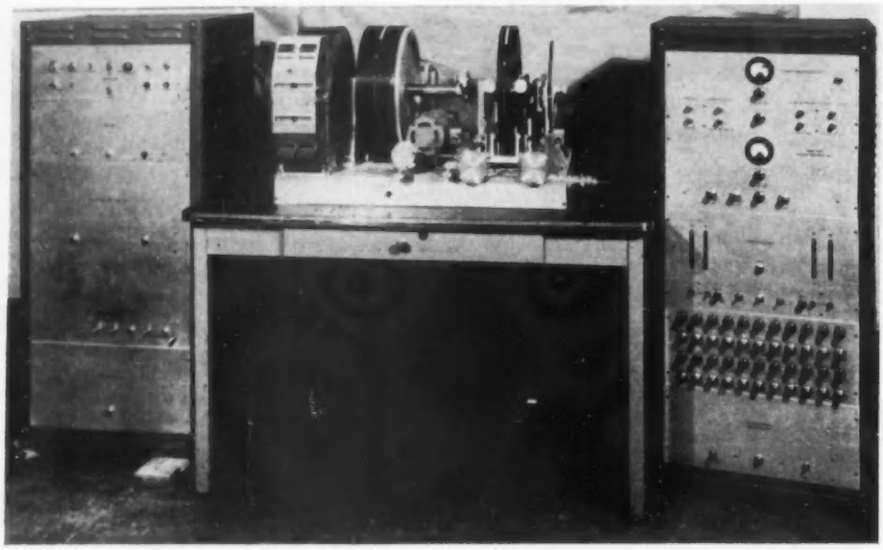


FIGURE 2—This is a view of Sohio Petroleum Company's data processing equipment used to upgrade tape recorded data. Equipment included is: tape transport unit in center, control panel and power supplies at left, and automatic data processing unit at right.

relatively low cost, it is good insurance. The ability to store information in an extremely versatile electrical media from which it can be transformed into mechanical motion, acoustical power, heat, light and fed to a computer for mathematical analyses appears sufficient reason for use of tape recording systems. Who can place a value on data whose permanence and versatility of form enable its analysis through systems and

About the Authors

C. F. Wendenburg, superintendent of the Geophysical Operations unit of Sohio Petroleum Company, graduated from The University of Texas in 1948 with a degree in physics. He joined McCollum Exploration Company after graduation and worked on problems involving the use of radar for marine geophysical surveying. He later was employed with Robert H. Ray Company, working in their laboratory on various geophysical problems. Wendenburg was employed by Sohio in 1955 as geophysical laboratory supervisor and has been active in the field of magnetic tape recording since that time.

John M. Sharpe, Geophysical Laboratory supervisor with Sohio Petroleum Company, attended Columbia University and the University of Delaware, majoring in electrical engineering. He has 12 years experience in radio communications and engineering with General Electric Company and the Federal Communications Commission. Prior to joining Sohio as chief geophysical observer in 1952, Sharpe was engaged in geophysical activities for six years with other companies.

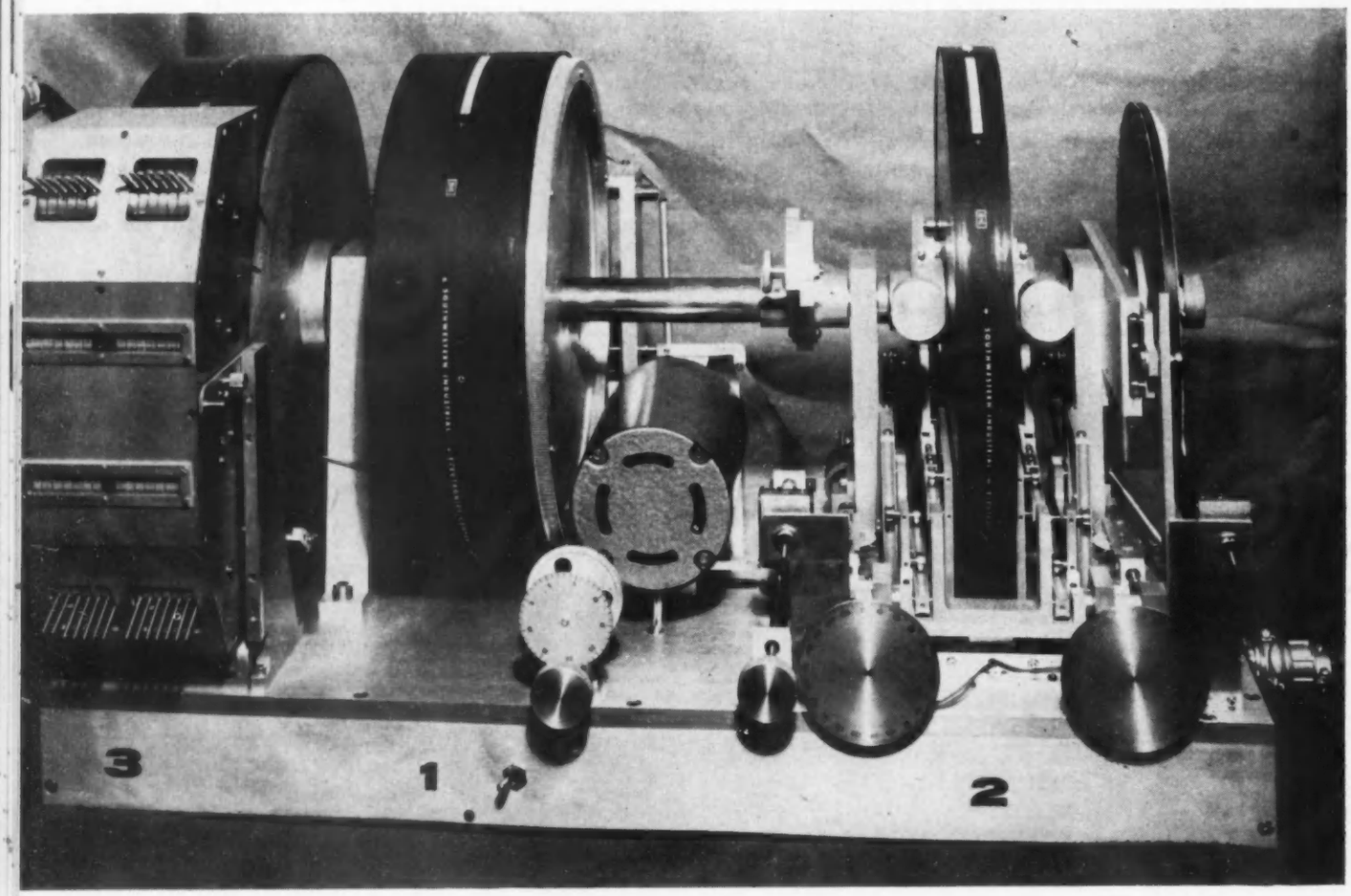


FIGURE 3—A close-up view of the tape transport unit shows the field tape drum (1), mechanism for correcting normal moveout (2), and the final tape drum where static corrections are inserted (3). Static corrections are made by adjusting the small rods on the front moveable head bank. The final tape on drum (3) is then recorded on film to produce the resulting seismogram.

equipment not yet invented?

The two seismograms in Figure 1 are examples of what has been done with tape recorded data. Both are playbacks from the same field tape. Record *A* shows unwanted noise interference completely overriding any desirable data that might be present. The other playback, record *B*, shows the information obtained from the same tape by the use of special processing techniques. It was possible in this particular case to obtain data by the use of a magnetic tape that would have been difficult to obtain otherwise.

On the other hand, if seismic field crews were in a position to employ the exact field procedure necessary to fit changing conditions at each shot hole location, there would be no need for tape equipment. The operation of many seismic field crews, except the experimental variety, is a compromise between quantity and quality of data. As long as the yardstick for measurement of crew performance is related to the dollar expenditures, whether the criteria be cost per hole, cost per profile or cost per mile, the economics will dictate the compromise between production and quality. This state of affairs would not exist if each shot hole could be treated as a separate survey. Consequently, this very condition places tape recorded data in a favorable position for quality improvement by the use of suitable playback methods.

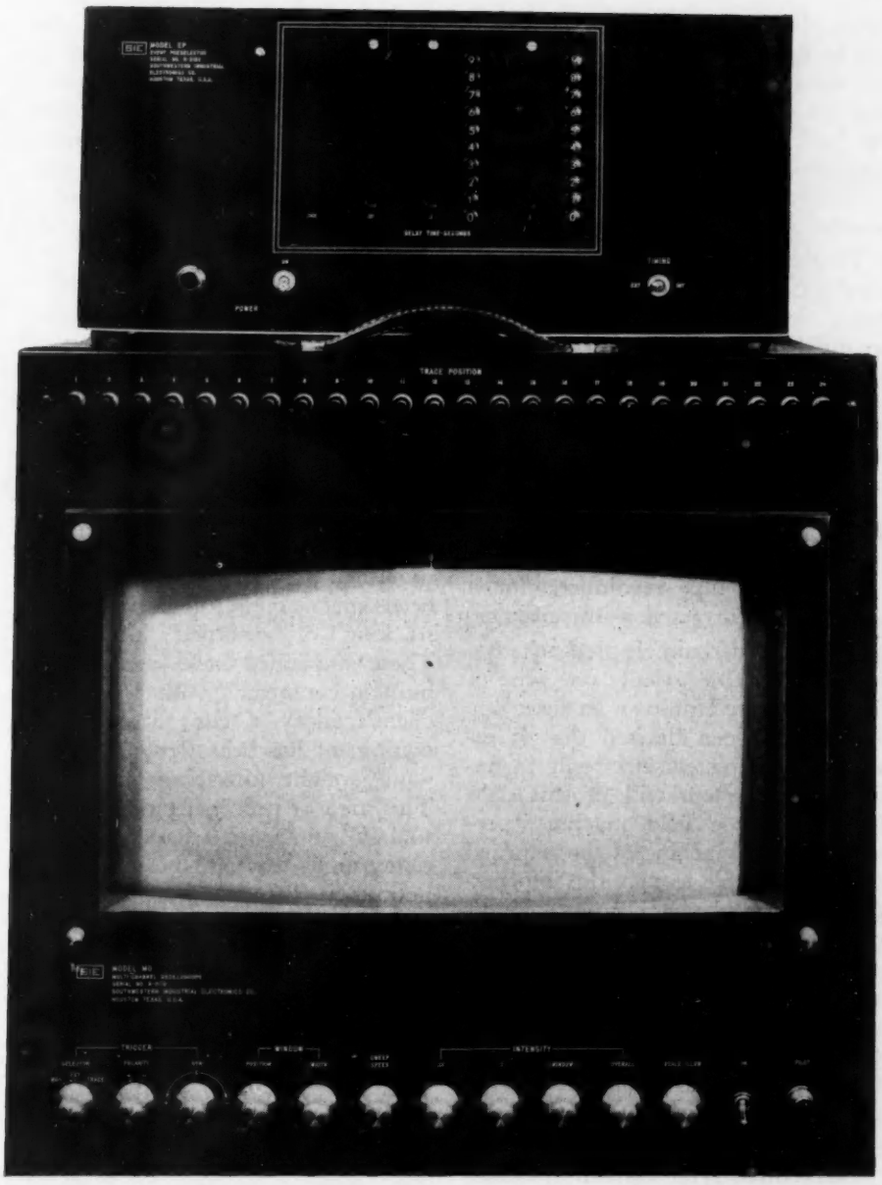


FIGURE 4—The multitrace oscilloscope is used as a visual aid in determining the success of a particular technique prior to making a final film seismogram. This equipment is normally mounted directly to the left of the head bank for convenience.

Field versus office processing. The use of tape recording equipment in conjunction with standard seismic recording amplifiers and filtering in the field limits the utility of the tape data due to the necessary simplification of equipment to maintain mobility and portability of field recording systems. It serves as a data storage function and as a more rapid and economical tool to determine the proper choice of the available amplifier filter in a particular area. In addition, it can be used as a seismogram duplicator, a device for applying computed corrections and a method for introduction of these corrections prior to mixing techniques. The resultant quality of playback seismograms is essentially limited to the admittance characteristics of the specific amplifiers and filters employed. These features may be sufficient justification by some companies for the utilization of tape recording, but for the majority of users, the greatest value of magnetic tape lies in the ability to upgrade data through the use of playback machines combined with special equipment and techniques.

Playback machines can be used either in a field office to serve the requirements of a particular crew's tapes or in a central location to process tapes for several operational crews. Both methods are in use at the present time. The field processing allows almost immediate use of the processed data. The central system has a certain time delay, although in some instances this has been reduced to a bare minimum of 24 to 48 hours. The field processing has the disadvantage, at least with some tape systems, of requiring a separate playback machine which constitutes a considerable capital investment. The versatility of a field playback system is usually limited to existing field amplifiers.

A central playback process has the advantage of reduced capital investment per crew as well as specialized treatment of data in many instances. When the data is processed in the central office location, technical advice from experienced higher echelon personnel is usually available to help overcome problems in processing techniques and interpretation. The processing equipment is generally

quite elaborate and more methods can be used in attempting to upgrade the data. The size, complexity, cost and power requirements of adequate playback facilities practically dictates the use of office playback equipment in order to fully realize the inherent possibilities of tape recorded data.

There are many different types of playback machines available for processing field data. Perhaps they can be divided into two general types:

1. Multi-channel systems make corrections to all channels simultaneously, and a corrected seismogram is obtained from one revolution of the tape.
2. Sequential machines correct one or two traces at a time, requiring a number of tape revolutions for a complete corrected seismogram.

Each multi-channel playback system is adaptable to only one type of field recorder. However, at least one system has been devised that is essentially completely electronic in nature. This system will process data from any type field machine, provided a field machine of the required type is available to play the information into the playback system. Multi-channel playback systems can usually process data more rapidly than the sequential channel systems. These machines are rather complex mechanically and are quite costly. Others are relatively simple but do not have the versatility of the more complex types.

Sequential type machines usually are made more versatile since they apply correction components to one or two traces at a time. Since practically all field recorders of the drum type, regardless of manufacturer, have approximately the same shaft speed or multiples of the lowest shaft speed, drums from different types of field machines can be mounted on the same shaft; and with suitable drive systems, the proper shaft speed can be obtained for each system. Thus, at a rather nominal cost, the sequential machine can be designed to accept and process field tapes from several different types of field recorders.

Some sequential systems incorporate pen writing devices or other means for display of permanent paper seismograms. These seismograms can be made individually or in cross-section form to suit the requirements of the user.

The sequential systems have definite advantages when attempts are made to upgrade data by the use of special equipment such as filtering. Only one or two filters are required instead of the 24 or more for multi-channel playback systems. Therefore, various experimental electronic devices for this use can be made at a low cost, and those that prove effective can be incorporated in the playback system.

The playback systems discussed have been used primarily for time corrections and for simplified experimental purposes to obtain better data. Other machines have been designed for processing tapes to obtain better results from specialized field shooting procedures. Several have been constructed for integration or stacking of recorded information. These machines have usually been built in conformity with a particular client's ideas. Other integration equipment has been designed for use with weight dropping techniques. This area of processing data appears to hold promise for better results in many areas through the use of magnetic tape. Tape equipment manufacturers are extremely cooperative and willing to undertake development of equipment based on any company's ideas. These ideas may encompass the over-all office playback system to suit the long-range policy of a company or contractor; or they may apply solely to certain specific tape equipment deemed necessary to handle problems peculiar in a certain geographical area of interest. In any case, manufacturers are most willing and ready to undertake solution to anyone's individual equipment problem.

Standardization of magnetic Tape systems. Standardization in the field of geophysical magnetic tape recording has been a frequently discussed subject. At present, there are numerous different types of field tape recorders and playback systems in use. Several oil companies have developed their own systems, and most manufacturers have several different models of field recorders for sale.

In the early days of field recorder design, each manufacturer attempted to gain a competitive edge and little thought was given to standardization. The manufacturers attempted to evaluate the performance of the various methods of modulation and tape dimensions. They designed their original machines in the way they hoped would be most acceptable to industry. After construction of a prototype machine, the manufacturer usually decided upon certain standards and characteristics and published advertising literature to this effect. At times, difficulty was encountered in producing machines on a production basis that would meet their original standards and redesign was necessary. This delayed the availability of such equipment. Production problems have been overcome at the present time and systems are available without extended delay. After a manufacturer had once committed himself to particular characteristics, standards and mechanical shapes, it was deemed too difficult and costly to incorporate basic changes in the system. Some special systems were designed to meet one particular purchaser's requirements; such machines also became available to the industry. Thus, there are many types of machines, and there is little that manufacturers can do among themselves to standardize the field machines as long as the purchasers' specifications are not standardized.

Although all manufacturers cannot easily standardize their equipment, each oil company has found it desirable and necessary to standardize on one or two equipment types. Some oil companies quickly realized the potential value in magnetic tape recording of seismic data and purchased the earliest available types in order to preserve the information on tape as soon as possible. Other companies evaluated the various systems and decided upon their ultimate objective in processing the tape before committing themselves to any specific system. After an evaluation of systems was made, each company, in general, standardized on one particular system and patterned their subsequent facilities to be used primarily with this equipment. This standardization was necessary to reduce the number of differing playback machines required to process the data. Thus, as any given manufacturer has committed himself to certain standards and mechanical shapes, many oil companies have committed themselves to a particular type of equipment.

An important contribution toward standardization can be in definitions

Continued on Page 150

Color aids photogeological interpretation

Aerial color photography is fast becoming an important tool in oil exploration due to interpretation advantages and reduced cost brought about by technological advances in film and processing.

By Dr. J. I. Gimlett and Kenneth E. Hunter
Hycon Aerial Surveys, Incorporated, Pasadena, Calif.

DURING THE PAST two years, aerial color photography has been developed into a new tool which can be applied economically to extend the scope of aerial surveying. In essence, aerial color photography refines detailed photogeological interpretation to a degree not previously possible with conventional black and white photography.

Aerial color film was developed during World War II for use in military reconnaissance. Extensive experimentation continued in the post war period, and by 1950 the film was available commercially. The art and science of photo interpretation itself was given new impetus by wartime research and military applications. Oil geologists have enthusiastically adopted photo interpretation as a means for obtaining geologic information concerning remote or inaccessible areas and have long since established it as a useful exploration tool.

The use of aerial color photography developed slowly, partly because of technical difficulties and partly because of the large measure of success afforded through interpretation of black and white photography. Sporadic attempts were made to use the new color film, but the many difficulties encountered led to discourgement with the new medium. In 1955, an aerial survey company began seriously experimenting with aerial color photography and through persistent efforts developed the techniques which have enabled them to offer it on a commercial basis.

In photogeologic interpretation of black and white photography, tonal differences play a small part. The tone is related to conditions such as granularity, moisture content and to differences in vegetation, rather than to differences in the underlying rock strata. Color, however, is a diagnostic feature of many natural objects and enhances the ability to interpret photographs by a very significant factor. Thus, the absence of color, a fundamental physical property, in conventional black and white photography handicaps the photo interpreter.

Most amateur photographers are aware of the fact that "true color" rendition can seldom be obtained. True color is physically an almost meaningless term since the color spectrum seen by the human eye or by a photographic emulsion depends on the sensitivity of the individual eye or emulsion to the various wave lengths comprising the visible spectrum. Provided that uniform results are attained and that the full range of colors are recorded, color transparencies provide the necessary information for detailed and accurate interpretation.

Some of the features of the color-sensitive emulsion as originally developed for military use made this film especially valuable for geologic purposes. The spectral characteristic of the emulsion was designed to provide maximum color contrast in those regions of the spectrum which are of interest to the photo-interpreter rather than to provide true color rendition. This, of course, results in severe limitations in applying precise spectrophotometric techniques, though filters can be used to compensate to some extent for spectral distortion.

It is of interest to note in this connection that an emulsion with special characteristics was developed to detect camouflage. With this film, green foliage which reflects infrared is rendered as red or magenta, whereas greens which absorb infrared, appear bluish; true reds appear as yellows. The development of this emulsion for a very special problem suggests possibilities for research into applications of this nature to geologic problems.

Color sequences in distinct rock units can be used in identification even when the units are widely separated in location. Key beds can be

Aerial color photography is particularly valuable in tracing formations in arid regions. This photo, flown at 22,500 feet, illustrates the large amount of structural detail visible. An anticlinal structure is clearly evident. Note apparent faulting in displaced beds in upper left hand corner. In color, the ability to trace and correlate key beds is greatly simplified. A stereo pair in this region yields more structural information in a day than could be obtained in the field in a month.

traced readily if even small color differences are discernible. Disturbances in a recognized color pattern reflect actual geological disturbances which would not otherwise be recognizable. Color offsets lead to recognition of faulting or fracturing within lithologic units. Metamorphism of sediments is generally accompanied by color differences. Small differences in hue are readily apparent to the eye and lead to delineation of fine detail which cannot be noted on black and white prints. With these special advantages, color photography still retains all of the inherent advantages of the photo geologic method.

It provides an over-all view of an area while ground surveys, from necessity have to be conducted from a more detailed point of view. It should not be inferred that these two methods are mutually exclusive; they are actually complementary.

South America furnishes a rather striking example of the use for color photography in oil exploration. Much of the topography consists of rugged mountains with outcrops and structures disappearing into jungles or pampas on the flanks where major basins occur. Aerial color photography is being used to trace the structures and formations seen in the mountains into the lowlands.

Recent work in the Four Corners area indicates that this, too, is a region in which color photography can be a useful tool. Here a very large section is exposed, a great deal of which is difficult to examine on the ground because of precipitous slopes. The topography and the aridity precludes abundant vegetation. Thus, many members of the stratigraphic

column can be followed over large distances by color alone.

The predominant colors, shades of red and buff, readily lend themselves to this method. The rugged terrain suggests that the art of photogrammetry would also prove useful in this region. The color transparencies themselves can be used in accurate stereoscopic plotting instruments, such as the stereoplanigraph, to obtain precise elevations on key beds with a minimum of field work. This dual use of aerial color photography is an economical, logical approach to the problem of geologic mapping in this region.

Photogrammetric techniques, such as the above, are gradually gaining recognition from geologists. Several oil companies have even bought Kelsh stereoplotters for use in compiling geologic and topographic data. Using first order stereoplanigraphs, it is possible to detect and measure closures too small for conventional observation with ground surveys. With these instruments it is possible to measure elevations to within 1/7,500 of the flight altitude. This means that elevations accurate to 0.67 feet can be obtained from 1:10,000 photography taken with a standard 6-inch mapping camera.

The engineering problems of interest to the oil industry concern pipe line rights-of-way and access roads for drilling rigs. In many areas soil analysis using color photography can be used to avoid bedrock trenching. Differences in vegetation as shown on color photography can help determine areas of firm ground in muskeg. It should be noted that color transparencies can be used as readily as black and white photography in most of the first-order stereoscopic mapping instruments. For other instruments, plates can be made readily from the color transparencies and compilation carried on in the usual manner.

It is true that little topographic mapping has been done to date from color photography. However, this is primarily due to the newness of the color field and to the increased cost of color over black and white rather than to any technical reason. In fact, experienced stereo compilers state that the color stereo model projected from color transparencies has greater visual acuity and is "harder" than its black and white counterpart. This, no doubt, is caused in part by the small grain in the transparencies. The fact that many objects, especially cultural features, can be more readily photo-identified in color is a significant aid in mapping. It is plausible that mapping accuracy as expressed by the C-factor (the flight altitude divided by the minimum possible contour interval) is actually increased by the use of color.

Securing color transparencies of high quality at an economical cost is not, it is true, as easily accomplished as the task of securing equivalent photographic coverage using panchromatic film. The higher cost is the result of a number of factors; higher film cost (500 percent higher), narrower exposure and developing latitudes, and higher reproduction costs.

At the present time, only one color film is available commercially for the standard cartographic camera, 9-inch by 9-inch format. This film has an emulsion speed of 40 ASA as compared to the 100 ASA exposure index of regular aerial panchromatic film. This means that light, as well as haze, conditions are more critical. Haze filters can be used but they have to be of the clear type which is not nearly as effective as the minus blue type used with black and white.

It should be noted that a new color film with an exposure of 100 ASA has recently appeared on the market. When this fast film or its equivalent becomes available for aerial cameras, the cost differential between black and white, and color will decrease.

The aerial color film has several advantages and one obvious disadvantage when compared to the most common color film type used for home movies and 35 mm slides. It is four times as fast; it has better color balance; and it can be developed in field darkrooms. Aerial color film uses silver halide to define relative light intensities the same as do all black and white films, and therefore will show grain in the finished transparency. The grain size is fortunately as small or smaller than that of regular aerial panchromatic film. The other type of color film has an entirely different type of emulsion, which contains no silver halide, and is therefore completely grainless. The development of a grainless aerial film for use in stereoplotters would have obvious merit.

Developing color film is inherently a more difficult task than developing panchromatic film as six solutions are needed instead of three. Moreover, the temperature of the initial developer has to be maintained to within one-half a degree of 70° F. This compares to the 65° - 70° F. range for regular black and white panchromatic film. It is apparent that more experience and greater care are necessary in color processing.

A technological advance along this line would be the development of a color film for which the laboratory processing is simpler and the temperature control less critical than for the films in use today.

In the eyes of a few critics, the chief drawback of color photography is the difficulty in obtaining good color reproductions. It is true that color prints are thus far prohibitively expensive. Even obtaining a duplicate roll of transparencies is expensive because of the high film costs. However, at the present time research is underway that is designed to decrease the cost of both color film and color prints. It is possible to make black and white negatives from color transparencies which are of comparable quality to those obtained from black and white negative film. This is possible because of the small grain size of this color film. The black and white prints made from these negatives can then be used in the conventional manner for field checking, for mosaics or annotation.

At the present time, the cost of aerial color coverage, depending upon local weather and haze conditions, is only about 30 to 50 percent higher than the cost of black and white coverage, rather than several times the cost as is commonly supposed. As a result of the aforementioned technical advances, this price differential should materially decrease in the future.

Although it has not reached the optimum in scientific development, color photography should still be the first choice for all photo interpretation purposes. The color itself provides more than a percentage increase in information. In addition, color photography, once obtained, can be used for many purposes, from photogrammetric mapping to the production of high quality black and white prints.

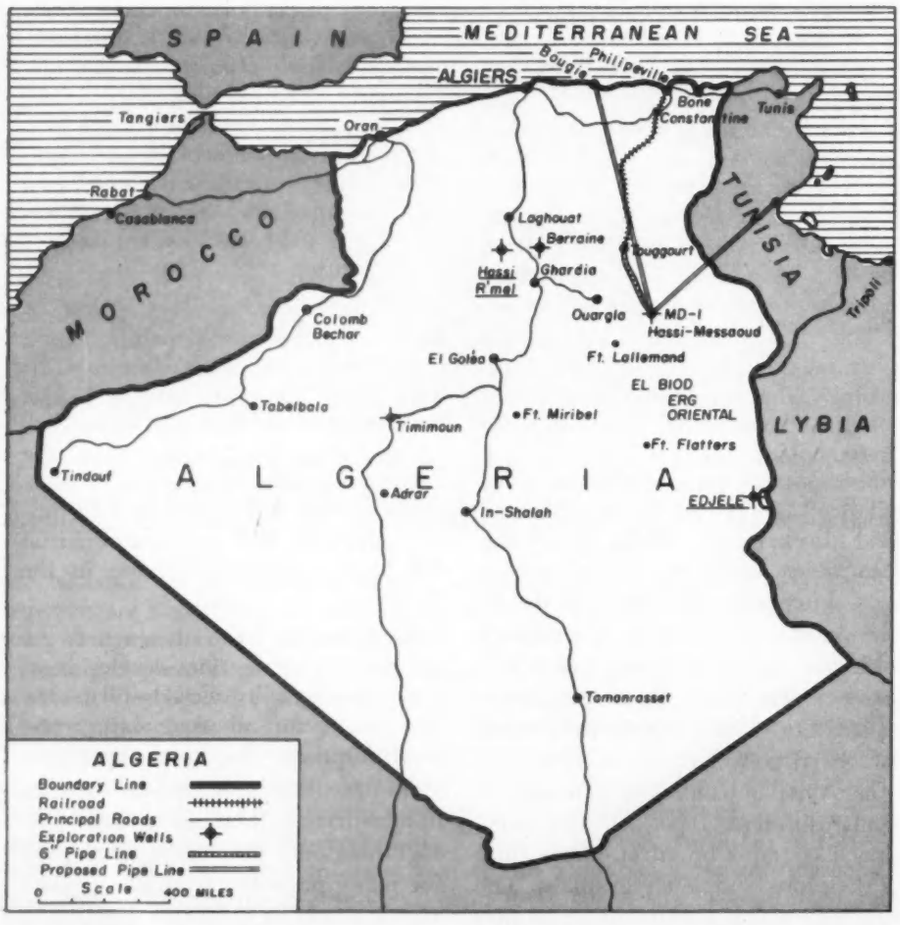
—The End

Algeria's Sahara: booming seismic frontier

An impetus of 1.5 billion barrels of potential oil in Algeria's Sahara desert spurs seismic crew activity for 1958.

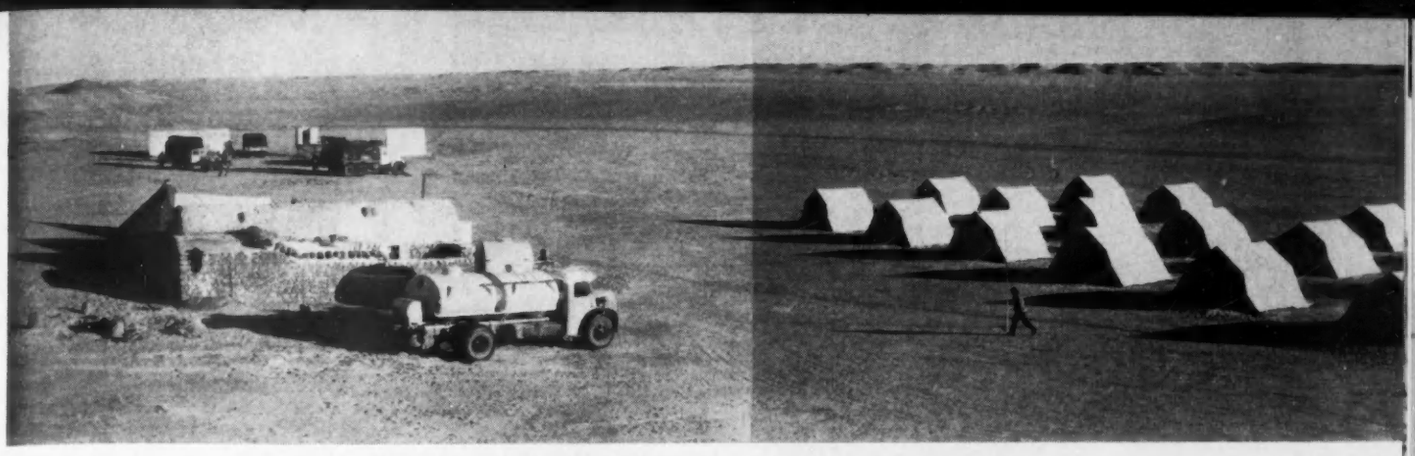
By Alan D. Waldie
McCollum Exploration Company, Houston

By the end of 1957, a total of some 20 seismic reflection and refraction crews (including two weight dropping crews) and four gravity crews were in operation throughout the Algerian Sahara desert. At that time, these crews were working on permits covering about 280,000 square miles—out of a possible 850,000 square miles—in a territory made geophysically complex by variable surface formations of hard and abrasive limestone or caliche, by an ill-defined water table, and also by the ever shifting sand dunes. In addition to these geophysical problems, there are many other physical obstacles which are making the task of geophysical prospecting quite burdensome.



Crews were searching for new geophysical finds on permits covering 280,000 square miles in the Algerian Sahara at the end of 1957. Note the pipe line from Hassi-Messaoud to Touggourt and the proposed lines to Bougie and to the Mediterranean across Tunisia.

Most common techniques not helpful. It was found from experience as early as 1953 (seismic operations began in 1951) that the conventional methods of seismic shooting crews, which were usually successful in other areas, would not give the desired results in the Sahara. For example, the first attempts to get records by using deep shot holes down to around 300 feet or more were generally unsuccessful. More often than not in the desert, the geophysical signal generated by the shot at this depth was obliterated by noise created by horizontal reverberation from near-surface formations of limestone or caliche and thick sandy beds which rest upon more compact formations. These factors, plus the prohibitive costs of this type operation, which are due to the difficult drilling conditions and the shortage of water, necessitated the development of newer and more effective techniques. The Sahara, like many parts of West Texas, as the Edwards Plateau or the Delaware Basin, has many complex geophysical problems which almost defy solution. Some of its areas are plagued with sustained



Sahara seismic party camp-water truck and mess hall on left with equipment maintenance and parking area to rear, quarters to right.

horizontally traveling reverberations, many more with multiples from subsurface formations and still other areas with both.

Since a low signal-to-noise ratio is the rule rather than the exception in this desert, a high multiplication factor (number of phones per trace times the shots used in the pattern) must be used to obtain seismic records of usable quality. In some areas up to 100 shots per pattern and 108 phones per trace are now being used to obtain readable records. A sketch of such a layout is shown in Figure 1. The shot holes used in an operation of this nature are usually drilled to depths of three to six feet by special drills developed for high production and portability.

To obtain the maximum cancellation of the objectionable horizontal energies and other noise, special consideration to layout distance between shot holes and also between geophones must be given to assure proper cancellation. As an example of one solution used, the distance between shot points in a pattern (Figure 1) was found to be at least 30 feet or more while the distance between geophones set out for each trace was 30 feet or more in a longitudinal direction, and 60 feet or more in a transverse direction. It was found that this method obtained the best results from a given number of geophones and shots.[1]

In the Sahara, it is possible to combine low frequency signals recorded over distances of 300 feet without too much attenuation due to move-out phase relationship. It has been proven that a proper filter setting allowed a considerable increase of distance between traces and shot points—shallow shots developing low frequencies are favorable to that setting. Without low frequency filters, seismic reflections in the Sahara would be almost impossible.[2]

Two areas in the Sahara have been confirmed as major fields. See Page 233.

Weight dropping technique introduced. When the aforementioned problems, such as the need for a large number of pattern shots and geophones (required for a high multiplication factor) were considered, it became evident that the introduction of the weight dropping technique to desert operations could be an important aid to the geophysical exploration program. The desired multiplication factors can be easily and cheaply obtained by using the weight drop method which generates the seismic energy by multiple impacts of a large weight dropped on the surface in a predetermined pattern without the need for shot holes or explosives.

Weight dropping experiments began in the Sahara in the summer of 1956. After these first experiments proved to be a geophysical success, by comparison with standard reflection records obtained by seismic shooting crews, a commercial practice of this technique began late that summer and continued through 1957.

Last December the first geophysical contractor's weight dropping system was installed in the Algerian Sahara. The weight dropper (thumper) shown in Figure 3 is designed for rapidly transporting the large three-ton weight from one drop position to the next as it simultaneously hoists this mass to a height of about 9 feet for the drop. At a time determined by the observer

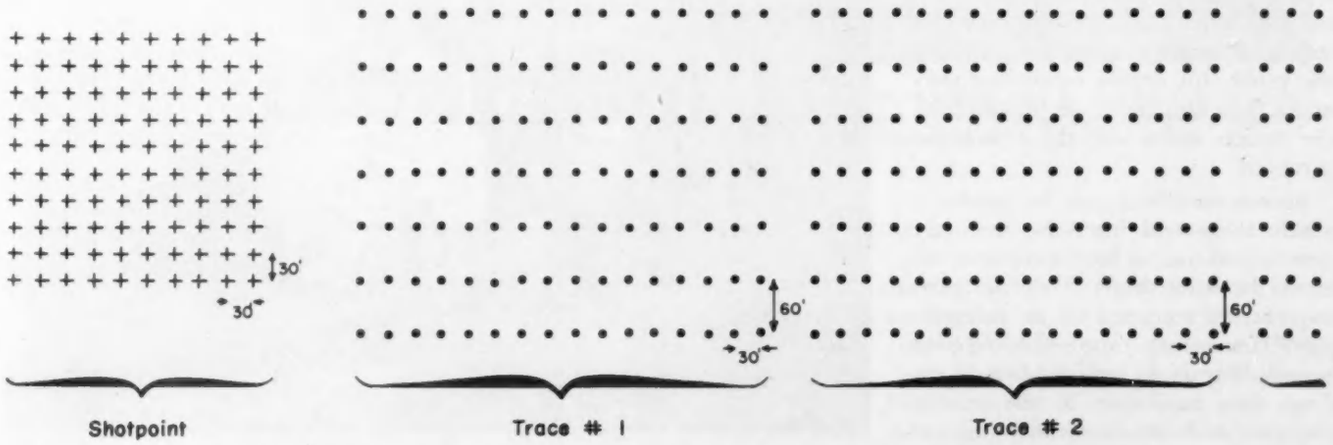


FIGURE 1—Example of pattern shooting (method) set up in the Algerian Sahara.

FIGURE 2—Hassi Messaoud's MD-1 well, producing 2000 barrels of oil per day from 11,000 feet and 450 feet of pay.

who operates the specialized tape recording instruments from another truck, the weight is dropped by radio. The resulting impact generates the seismic signal into the ground. It may be of interest to note that the power set up by the weight impact of a 9-foot fall is equal to about one-half ounce of 60 percent gelatine dynamite. However, the elastic energy set up by the falling weight by actual comparison to dynamite in field tests was found to be between 100 to 1,000 times more efficient (depending on surface conditions).

The seismic energy created by the weight drop is reflected by the subsurface formations and received by several detector stations spaced along the profile for proper subsurface coverage. The number of geophones used per station varies with the area being surveyed.

Successive drops can be made in about 12 second intervals, the time determined mainly by the distance selected between drops. They are then sequentially recorded on an integrating FM magnetic tape recording field system (Figure 4), which corrects for drop time variations of the seismic energies and simultaneously records this information from the detector stations. These recorded magnetic are then sent for processing to a central office playback and analysis system.

General office processing. The central office machine (Figure 5) is a form of analog computer designed to correct the field tapes for both static (weathering, dip, elevation etc.) and dynamic (normal move-out) corrections. This is necessary in order to time-align the recorded seismic events for integration (compositing) of these events from multiple drops to improve the signal-to-noise ratios for record

FIGURE 3—Hydraulic weight dropper first used in Sahara in December, 1957.

quality. The final corrected drops recorded are photographed by this analyzer with a special synchronous camera that completes the seismogram as a part of a record cross-section corrected to a pre-selected datum plane. The individual records (if desired) may later be put together for a complete cross-section of the line under survey.

Problems of desert transportation. Since the centers of production are so widely scattered, the distances to be covered, along with the scarcity of water and the instability of the sandy soil, create an acute transportation problem for most all geophysical and oil operations. For 1957 the supplies needed for oil prospecting and production alone were more than 10 million useful tons per mile of road traveled, and it is estimated that this will be doubled in 1958. Normally 90 percent of this material should go by road. At the present time, however, the road system in Algeria is insufficient to sustain transportation needs in the desert. The road system of Algeria covers 516 miles of national roads, 7,776 miles of principal tracks, and 8,295 miles of secondary tracks without highway or paving. (The total area of Algeria is about 850,000 square miles, as compared to 266,000 square miles in Texas.)

A program to deal with the immediate needs providing for the construction of a Ghardaia-Ouargla-Hassi Messaoud-Ft. Flatters road is underway at an estimated cost of 28 million dollars at a rate of about 0.62 miles per day. (Ninety per cent of all building equipment must be imported.)

Air transportation necessary. At present air transportation appears to be the most satisfactory means in the desert region. Regular lines run between principal cities carrying personnel and about 80 percent of the necessary supplies. Air time from Algiers to Hassi-Messaoud is about two and one-half hours while the same distance covered by road requires five days. However, airlines are costly to run and the airplane does not do away with the need for developing more ordinary means of transportation, especially for heavy material and supplies.

Oil exports. The biggest problem which yet remains is that of successfully getting the oil out of the desert for export. At present, one 6-inch pipe line has been completed and is in operation from the MD-1 well at Hassi-Messaoud and north about 112 miles to Touggourt, the nearest railroad. The crude goes by rail 350 miles to Phillipeville on the coast where it is then placed in tankers for export (see map). Since it is expected that the oil fields in Algeria will produce 50 million barrels of oil per year by 1960, it is evident that considerable construction of pipe lines and pump stations will be needed to handle this production. A French pipe line company plans a 24-inch pipe line in 1958 from Hassi-Messaoud to the Mediterranean across Tunisia and also another line north from Hassi-Messaoud

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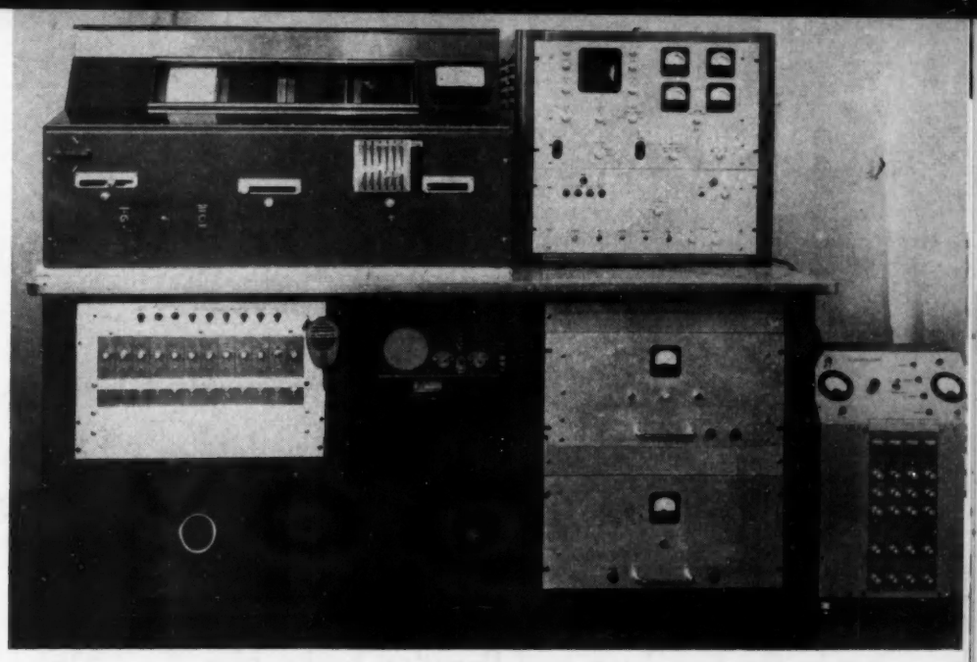

FIGURE 4—Specialized field tape recording equipment used to sequentially record the seismic weight drop information.

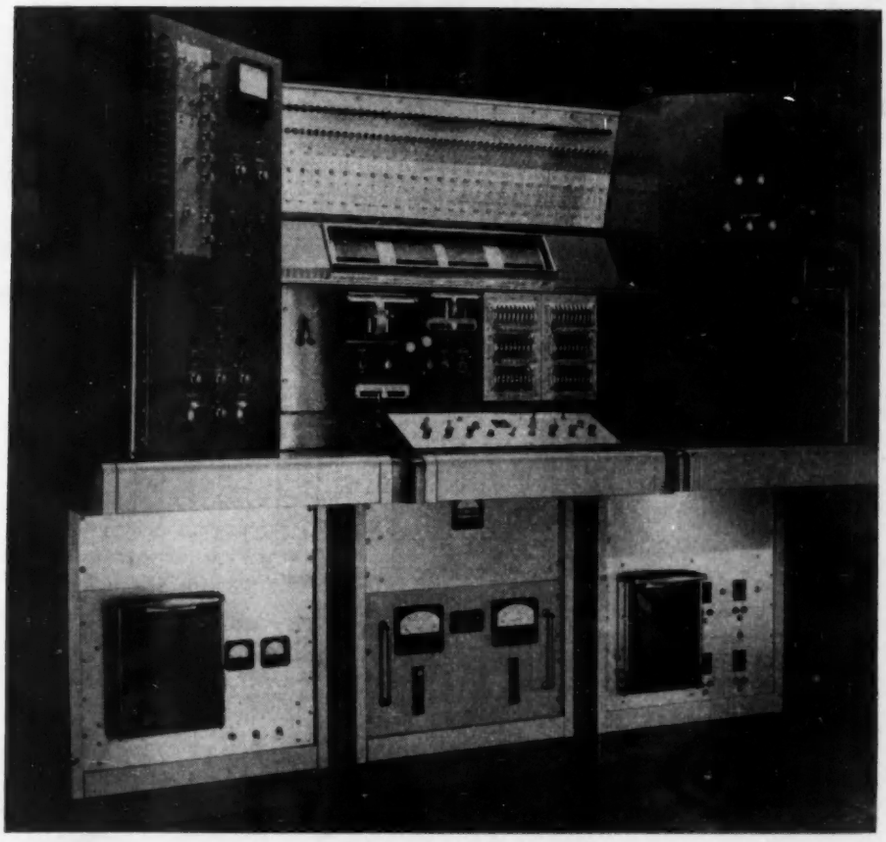

FIGURE 5—A central office playback tape machine used to correct field magnetic tapes for static and dynamic (normal movement) variations. This machine composites and photographs drop recordings into usable seismograms.

What's the outlook for . . .

Geology and exploration in the Four Corners?

Deeper possibilities, large unexplored structures and known reserves existing in the San Juan and Paradox basins plus the added attraction of the relatively unexplored Black Mesa Basin are causing many operators to focus their attention on this "hot spot."

By Bert F. Gray, Jr., Northwest Production Corporation, Albuquerque, N. M.

THE FOUR CORNERS area appears to have a bright future. Increased cost and difficulty of finding oil in some of the other oil-producing regions in the United States have caused many operators to turn their interest toward this "hot spot." One incentive has been that oil can be found and produced from relatively shallow drilling depths at reasonable costs. Deeper possibilities also exist, and many large structures indicate a future potential for exploration.

This area, lying in the common corner of the states of Colorado, Utah, Arizona, and New Mexico has three major geologic basins: the San Juan Basin, located in northwestern New Mexico and southwestern Colorado; the Paradox Basin, located in southeastern Utah and southwestern Colo-

PERIOD	EPOCH	FORMATION	FIELDS
CRETACEOUS	MONTANA	KIRTLAND (FARMINGTON)	AZTEC ○ BLANCO ○ BLOOMFIELD ●
		FRUITLAND	AZTEC ○ GALLEGOS ○ WEST KUTZ CANYON ○ IGNACIO ○ BONDAD ○
		PICTURED CLIFFS	BLANCO ○ GAVILAN ○ KUTZ CANYON ○ FULCHER BASIN ○ ROSA ○ IGNACIO ○
	MESAVERDE GROUP	CLIFF HOUSE MENEFEE POINT LOOKOUT	BLANCO ○ N.E. BLANCO ○ RED MOUNTAIN ● STONEY BUTTE ● BONDAD ○ IGNACIO ○ BARKER DOME ○
		GALLUP	BISTI TREND ● HORSESHOE CANYON ● VERDE GALLUP ● HOSPAH ●
	COLORADO	MANCOS TOCITO LENTIL	DOSWELL-LOWRY ●
		DAKOTA	ANGELS PEAK ● BARKER CREEK ○ HOGBACK ● RATTLESNAKE ● TABLE MESA ● UTE DOME ○ RED MESA ○
JURRASSIC		MORRISON ENTRADA	IGNACIO ○ TORREON ●
TRIASSIC			
PERMIAN			
PENNSYLVANIAN	VIRGIL		
	MISSOURI	UPPER HERMOSA	
	DES MOINES	PARADOX	BARKER CREEK ○ RATTLESNAKE ● UTE DOME ○
		LOWER HERMOSA	
	ATOKA		
	MORROW		
MISSISSIPPIAN	MERAMEC OSAGE KINDERHOOK	LEADVILLE	RATTLESNAKE ● TOCITO DOME ○
DEVONIAN	UPPER	OURAY	RATTLESNAKE ● TOCITO DOME ○
ORDOVICIAN		UNNAMED	
CAMBRIAN			

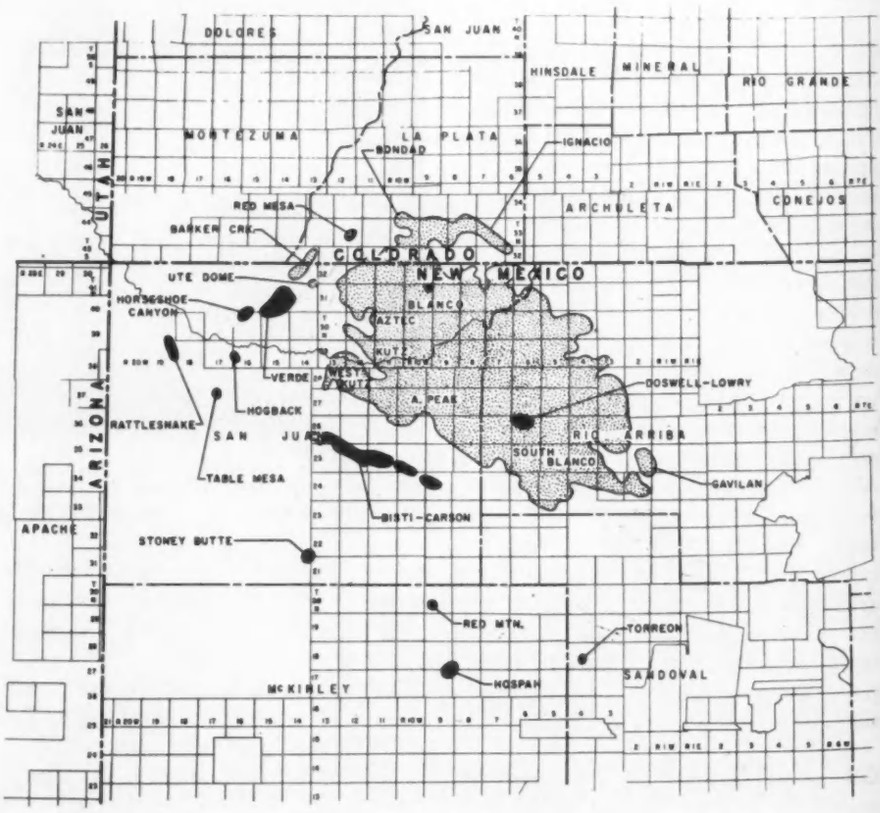

FIGURE 1—Geologic column map of San Juan Basin showing oil and gas fields.

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PERIOD	EPOCH	FORMATION		FIELD
CRETACEOUS	COLORADO	MANCOS		
		DAKOTA		
JURRASSIC	UPPER	MORRISON		
	LOWER	SAN RAFAEL GROUP		
TRIASSIC	UPPER	SHINARUMP		MC ELMO ☼
	LOWER	MOENKOPI		
PERMIAN	LEONARD	COCONINO SS		BOUNDARY BUTTE ●
PENNSYLVANIAN	VIRGIL	UPPER HERMOSA		BOUNDARY BUTTE ● ☼ E. BOUNDARY BUTTE ● ☼
	MISSOURI			ANETH ● BLUFF ● TURNER BLUFF ● BLUFF BENCH ● RUTHERFORD ● ISMAY ● RECAPTURE CREEK ● AKAH ● ☼ BITA PEAK ☼ TOHONADLA ●
	DES MOINES		PARADOX	DESERT CREEK ● ANETH ● BLUFF ● RUTHERFORD ● CAHONE MESA ● WHITE MESA ● GOTHIC MESA ● DOVE CREEK ● CHINLE WASH ☼ MC ELMO CREEK ●
		LOWER HERMOSA		
	ATOKA			
	MORROW			
MISSISSIPPIAN	MERAMEC OSAGE KINDERHOOK	LEADVILLE		BIG FLAT ●
DEVONIAN	UPPER	ELBERT	DOLOMITE MEMBER MC CRACKEN SS	
ORDOVICIAN				
CAMBRIAN	UPPER	LYNCH DOLOMITE		
	MIDDLE	BOWMAN HARTMAN & OPHIR		
	LOWER	TINTIC QUARTZITE		

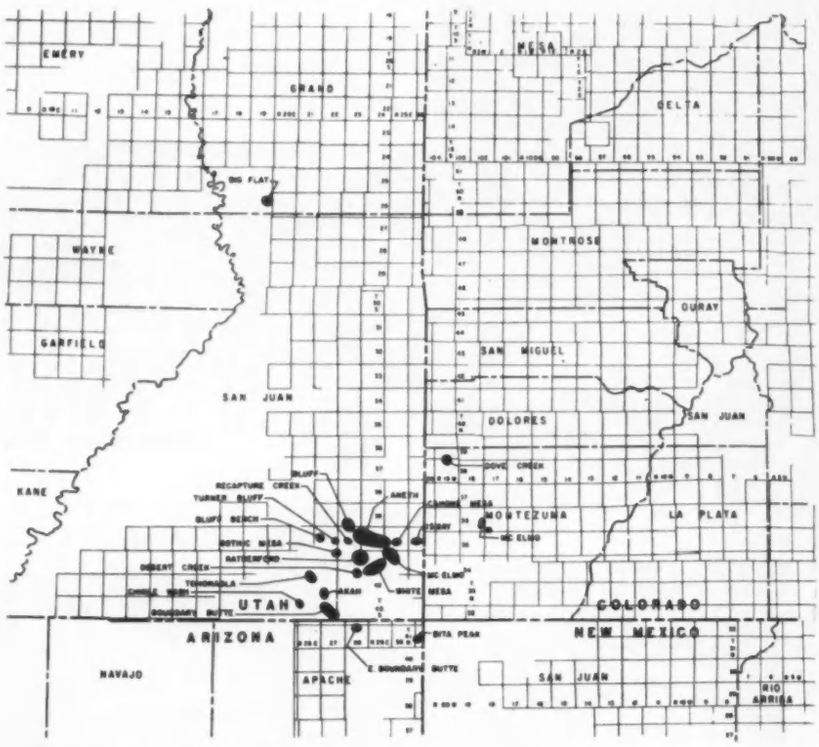

FIGURE 2—Geologic column-map of Paradox Basin showing oil and gas fields.

rado; and the Black Mesa Basin, located in northeastern Arizona.

Development of the Pictured Cliffs and Mesaverde, producing vast gas reserves from the center of the San Juan Basin, is declining. Obvious structures that have been drilled with unfavorable results show favorable possibilities for oil and gas traps on the flanks of the larger structures. If structures of pre-Pennsylvanian age can be outlined in the Paradox Basin, the possibilities for Mississippian and Devonian production should be very good. The Pure Oil Company's oil discovery at Big Flat has made operators aware of the Mississippian potential. Increased activity may result in appreciable additions to oil reserves of the Paradox. The Black Mesa Basin, relatively unexplored, has many large undrilled anticlinal structures. This area should receive considerable attention in the future, as indicated by the recent Navajo Indian lease sale.

San Juan Basin. The San Juan Basin (Figure 1) is located in the northwestern corner of New Mexico, with a small portion of the basin overlapping into southwestern Colorado. The basin is bounded on the north by the San Juan dome and the Four Corners platform, on the west by the Defiance uplift, on the south by the Zuni uplift and on the east by the Nacimiento uplift and the Archuleta anticlinorium. These tectonic elements have resulted in the San Juan Basin being an asymmetrical geosyncline, with the northeast flank being the short steep side.

The San Juan Basin has been known for its vast gas reserves for several years, but only in the past two years has oil production become of major importance. The first oil production was discovered in the 1920's. Nogback, discovered in 1922, produces oil from the Dakota formation of Cretaceous age. Rattlesnake, discovered in 1924, produces from the Dakota formation of Cretaceous age. Later oil was discovered in the Hermosa formation of Pennsylvanian age. Hospah, discovered in 1925, produces oil from the Hospah sanstone of the Upper Gallup member of the Mesaverde group. These oil discoveries were drilled on anticlinal structures and are considered to be structural accumulations of oil. More recent oil discoveries in the San Juan Basin have been in stratigraphic traps.

Doswell-Lowry. The Lowry Field was discovered in July, 1951, and is located in T26N, R6W, Rio Arriba County, New Mexico. The producing zone is the Tocito, a sandstone lentil of the Mancos formation. This field is a stratigraphic trap in the sense that the sandstone lentil becomes shaly and impervious updip, which makes the trap for the accumulation of oil. Reserves in the Lowry field are estimated at 576 barrels per acre-foot in place with 3,200 acres within the proved area and an average pay thickness of 13 feet.

Verde-Gallup field. This field discovered in October, 1955, is located in T31N, R14W and R15W, San Juan County, New Mexico. Oil production is from the Gallup member of the Mesaverde group (Figure 1). The initial wells showed Verde-Gallup to be producing from a fractured reservoir. The proved area of this field is approximately 5,200 acres with an estimated 2,000 barrel per acre recoverable. In 1957, Tom Bolack drilled the discovery well in the Horseshoe Canyon field. This field also produces from the Gallup sandstone and is located in T30N, R16W, three miles southwest of the Verde-Gallup field. Drilling depths range from 1,300 to 1,600 feet. The proved area constitutes approximately 1,200 acres, with estimated 500 to 700 barrels per acre foot in place and an average pay thickness of 45 feet.

Bisti field. Bisti was discovered in October, 1955, by El Paso Natural Gas Company's Kelly State 1, Section 16, T25N, R12W, San Juan County. Production is from the Gallup sandstone of the Mesaverde group (Figure 1). This field covers parts of T25N and 26N, R10, 11, and 12W, San Juan County, New Mexico, and is the largest oil field discovered in the San Juan Basin to date. The field is on the south flank of the basin and the accumulation of oil is the result of a facies change in shoreline and nearshore deposits. This marked facies changes is from a permeable-type sandstone, to an impermeable siltstone and silty carbonaceous shale both updip and downdip. The sandstone reservoir is characteristic of an offshore sand bar and strandling of a land mass of low relief which has been doposited under regressive marine conditions.

The structure contours of the field show gentle north dip with the structure having no effect on the accumulation of the oil. Limited hydrodynamic action is suggested by the fact that brackish waters have been encountered on the southwest, or updip, side of the field. Approximately 19,000 acres have been proved productive with a primary recovery estimated at 1,400 barrels per acre.

Gas production in the San Juan Basin was first discovered at Aztec, N. M., in 1920. Production was from the Farmington member of the Kirtland formation. Since 1920, gas has been discovered at Ute Dome, Barker Dome, Kutz Canyon, Fulcher-Kutz, Blanco, LaPlata and Ignacio. The Dakota and Pennsylvanian gas at Barker and Ute domes was the first to be produced heavily, but the tremendous gas reserves of the San Juan Basin come from the Pictured Cliffs and Mesaverde formations (Figure 1).

The Pictured Cliffs formation of Cretaceous age was first productive at Fulcher-Kutz in 1927. Since that time, gas in the Pictured Cliffs has been proved productive in over 850,000 acres and has an estimated 6.4 trillion cubic feet of recoverable gas. The pictured Cliffs is a massive, fine- to medium-grained sandstone and is gradational into the underlying marine shales of the Lewis formation. The northwest-southeast alignment of the porous trends in the Pictured Cliffs is indicative of a shoreline deposit of a regressive sea, resulting in the formation of a stratigraphic trap for the accumulation of the gas.

Although the Blanco gas field was discovered in 1926, development of Mesaverde gas reserves was not started until 1945. Since initial development, the Mesaverde reserves now extend over 1,054,295 acres with recoverable reserves of 24 trillion cubic feet of gas. During peak productive days in 1957, as high as 1 billion cubic feet of gas per day was being produced from the San Juan Basin.

The Mesaverde is composed of alternating massive sandstones, carbonaceous shales and coals. The depositional environment was that of transgressive and regressive seas.

Outlook for San Juan Basin. Although the gas development of the Pictured Cliffs and Mesaverde in the center of the basin is declining, it is anticipated that the Dakota and Gallup will get intensive drilling in the future.

The Gallup appears attractive because it is present in the shallower portion of the basin. Continued drilling in the southern part of the basin should produce trends similar to the Bisti.

The Dakota and overlying Graneros afford good sandstone reservoirs and are being exploited. As more wells are drilled, the added subsurface information will undoubtedly aid in the discovery of more oil and gas in the Dakota-Graneros section.

The marine Paleozoic section is present over much of the basin (Figure 1). Although excessive depths are required to reach them it is believed that the Paleozoics have good chances for production.

On the east and northeast side of the basin the Paleozoic sediments are truncated. The Mesozoic sediments thin very rapidly in this area because of the Archuleta anticlinorium. Although the crests of several obvious structures have been drilled with unfavorable results, it is possible that the flanks of the larger structures, in combination with regional thinning and uncomformities, afford excellent possibilities for oil and gas traps.

Paradox Basin. The Paradox Basin is an elongate northwest-southeast trending sedimentary basin of Pennsylvanian age. It is located in southeastern Utah, extreme northeastern Arizona, southwestern Colorado, and northwestern New Mexico (Figure 2). The basin is outlined by the presence of the evaporite facies of the Paradox formation of Pennsylvanian age. It is also bounded by post Pennsylvanian tectonic elements, which aid in outlining the basin. Tectonic features, which help define boundaries for the Paradox Basin, are the Uncompahgre on the north and northeast, the Four Corners platform on the southeast, the Defiance uplift and Tyende-Saddle on the south, and the San Rafael swell and Circle Cliffs uplift on the west and northwest.

Oil had been produced in the Mexican Hat field as early as 1907, but it has been only in the past three years that the Paradox Basin has become an important oil producer.

The Paleozoic section of the Paradox Basin is comprised of beds of Permian to Cambrian age with the exception of the Silurian, not deposited with this basin (Figure 2). Although the Cretaceous, Jurassic, and Triassic are present in the basin, they have not contributed to oil and gas production, with the exception of the Shinarump formation of Traissic age, producing at McElmo Dome.

In 1954, Shell Oil Company completed the Desert Creek 2, Sect. 35, T41S, R23E, San Juan County, Utah, for approximately 200 barrels per day on choke. Since the Desert Creek 2 was discovered, increased drilling has resulted in the discovery of major oil fields. There are two producing zones in these fields. They are the Upper Hermosa and Paradox members of the Hermosa formation of Pennsylvanian age. The lower portion of the Upper Hermosa is termed the "Bluff zone" and produces at North Boundary Butte, East Boundary Butte, Recapture Creek, Ismay, Bita Peak, Bluff, Aneth, Turner Bluff, Bluff Bench, Akah, Tohanadla and Ratherford (Figure 2).

The Desert Creek zone grades from marine partially dolomitized limestones to dolomite and salt. This zone is a partial evaporite cycle. The zone has been referred to as reefoid and gives the appearance of reef breccia. It is bounded above and below by black shales, very good markers for detailed correlation. These black organic shales are possibly the source for oil and gas.

The bluff zone overlies the black shale marking the top of the Desert

Creek zone and is predominately a fossiliferous vuggy limestone of shelf facies.

These oil fields are reported by the Utah Oil Commission to have approximately 32,320 acres within their field limits. It is estimated that 400 to 500 barrels of oil per acre-foot will be obtained during primary recovery. The pay ranges from 50 to 150 feet in thickness.

Gas fields that have been discovered in the Paradox Basin are also shown in Figure 2. These fields have approximately 1,440 acres proved productive.

One of the more significant discoveries in 1957 was The Pure Oil Company's Big Flat Unit 1, Sect. 14, T26S, R19E, Grand County, Utah (Figure 2). This well was completed for 319 barrels of oil per day from the Mississippian and is Utah's first Mississippian.

Outlook for Paradox Basin. The Pennsylvanian Hermosa and Paradox formations will get intense drilling in the future. With the added subsurface information, additional porous and permeable trends should be delineated. Numerous salt anticlines occur within the Paradox Basin, but to date no commercial quantities of oil have been found on these features. But the flanks of these structures have possibilities for production.

The Pure Oil Company's discovery at Big Flat in Grand County, Utah (Figure 2), has made operators in the Paradox Basin aware of the potential that the Mississippian offers. With increased drilling activity, it is believed that the Mississippian will add appreciably to the oil reserves of this Basin.

The Upper Devonian Elbert formation, composed of an upper dolomite member and the McCracken sandstone member, has very good reservoir characteristics. Numerous oil stains and shows have been encountered in this formation, but as yet oil has not been produced from the Devonian in the Paradox Basin. If structures of pre-Pennsylvanian age can be outlined, the possibilities for Mississippian and Devonian production should be very good.

Black Mesa Basin. The Black Mesa Basin is located in the northeastern part of Arizona. The tectonic elements bounding the Black Mesa Basin are the Defiance uplift on the east, the Tyende saddle and Piute folds on the north, the Kaibab uplift on the west and the Mogollon slope on the south. The Black Mesa Basin covers approximately 7,000 square miles and has been relatively unexplored. The basin has many large undrilled anticlinal structures. The structures, combined with the existence of marine Paleozoic sediments, make the basin very attractive for exploration.

The Black Mesa Basin should receive considerable attention in the near future. Interest in the basin is reflected by the recent prices paid for leases located on the saddle separating the Paradox and Black Mesa Basins. These leases sold as high as $213.36 per acre in a recent Navajo Indian lease sale.

BIBLIOGRAPHY

R. W. Allen, Stratigraphic Gas Development in the Blanco-Mesa Verde Pool of the San Juan Basin, *Four Corner Geological Society Guidebook,* 144 (1955).

George Herman and Clifford A. Barkell, Pennsylvanian Stratigraphy and Productive Zones, Paradox Salt Basin, *AAPG Bulletin,* Vol. 41, 861 (1957).

Vincent C. Kelley, Tectonics of the Four Corners Region, *Four Corners Geological Society Guide Book,* 108 (1955).

Val R. Reese, Pictured Cliffs and Fruitland gas Developments of the San Juan Basin, Northwestern New Mexico and Southwestern Colorado, *Four Corners Geological Society Guidebook,* 137 (1955).

J. Q. Tompkins, Bisti Oil Field, San Juan County, New Mexico, *AAPG Bulletin,* Vol. 41, 906 (1957).

ACKNOWLEDGMENT

This article condensed from a paper presented at the spring meeting of the Southwestern District, Division of Production, API, Fort Worth, March, 1958, under the title of "Geology and Exploration Outlook for the Four Corners Area."

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Algeria's Sahara

Continued from Page 122

to Bougie. The fields at Hassi-Messaoud alone have an estimated potential of 1.5 billion barrels of oil.

American companies want permits. Five American oil companies have requested permission to prospect for oil in the Sahara beginning in 1958 for the next five years. The companies applying are Sinclair, Pan American Petroleum, Cities Service, Newmont Mining and Canadian Delhi Company.

Future prospects. Continuous progress is being made in geophysical methods and techniques leading to the development of special techniques for faster pattern shooting. Weight dropping methods show promise for faster, cheaper and safer productive methods in obtaining better seismic records through specialized tape recording systems and central office processing methods. Many new geophysical finds will undoubtedly be made to bring the proof through drilling that the Sahara can be considered henceforth an "oil-bearing province."

ACKNOWLEDGMENT

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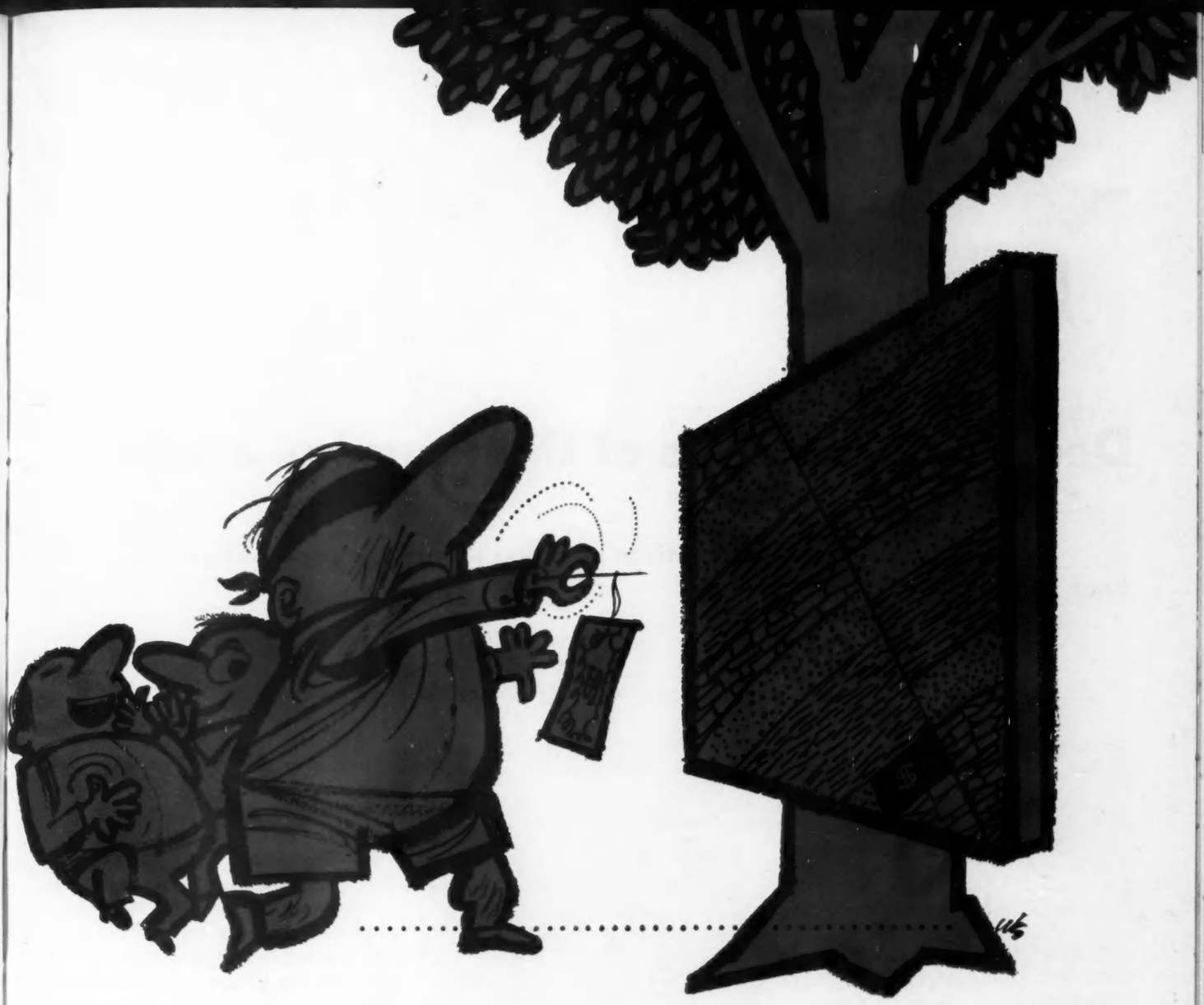
REFERENCES

[1]Talk presented by M. Pieuchot (Compagnie Generale de Geophysique as SEG Convention in November 1957.
1957.

[2]Ibid.

About the Author

Alan D. Waldie, chief engineer for McCollum Exploration Company, Houston, graduated from Texas A. & M. College in 1951 with a B.S. degree in electrical engineering. After two years as a U.S. Army Signal Corps officer he joined McCollum in 1953. Waldie is a member of the SEG, IRE and a first vice president of the Houston Geophysical Club.



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Deeper possibilities of the Paradox studied

Operators are directing their attention toward the pre-Pennsylvania in this Four Corners "hot spot."

By Dr. Carl A. Moritz, Chief Geologist, Alex W. McCoy Associates, Incorporated, Tulsa

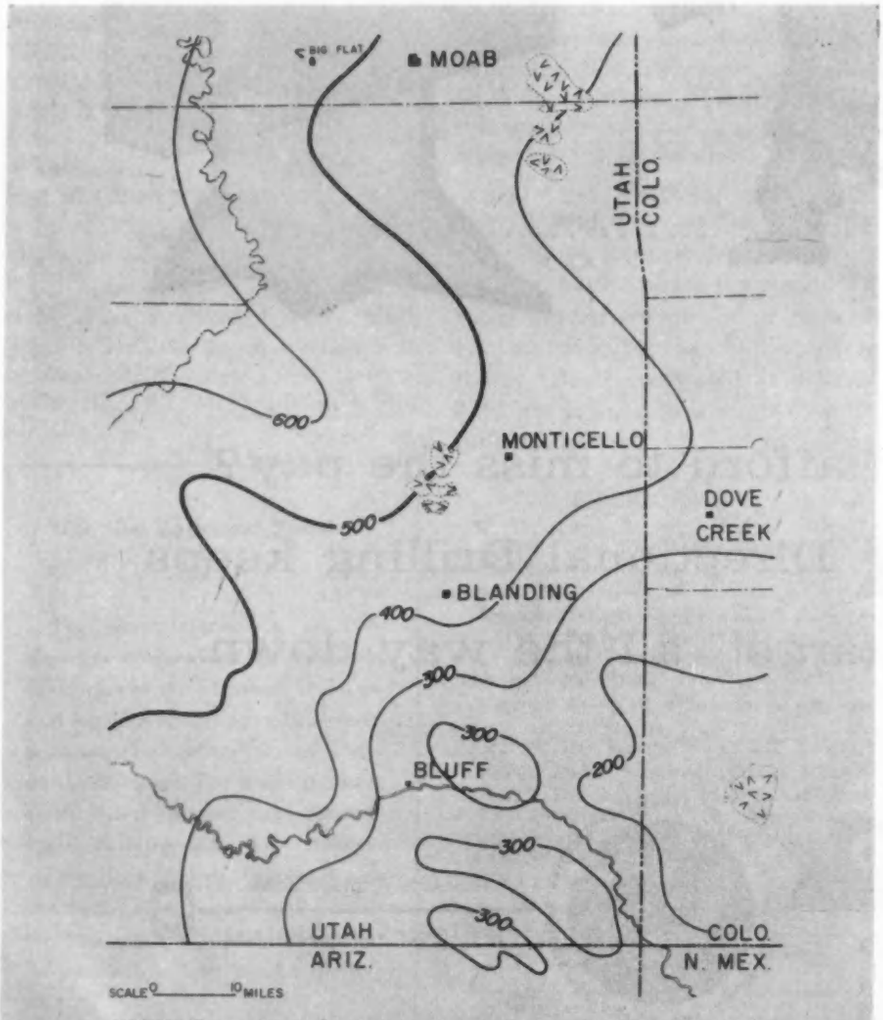

FIGURE 1—Generalized isopachous map of the Mississippian system. Isopachous interval is 100 feet.

ONE OF THE most significant discoveries in the Rocky Mountain region during 1957 was The Pure Oil Company's discovery of Mississippian oil at Big Flat in Grand County, Utah. The Big Flat Unit 1 is especially important because it emphasizes the importance of a large sedimentary basin in which the pre-Pennsylvanian rocks are practically untested.

Since the Mississippian discovery at Big Flat, operators have been directing attention to the pre-Pennsylvanian zones, as well as to the Hermosa and Paradox formations.

The Mississippian attracted some attention at least two years earlier. In 1955, King Oil Company completed a Mississippian well at Big Flat, but it proved non-commercial. The Pure Oil Company Big Flat Unit 1 is the first commercial Mississippian oil well in Utah. It was completed through perforations from 7,694-7,728 feet and had an initial potential of 319 barrels. After a 15-day production test, the production levelled off at 175 barrels. The operators estimated that the well is capable of producing approximately 300 barrels per day on pump. The 43-gravity oil is a sour crude.

Mississippian system. The nomenclature, age and correlation of the Mississippian rocks in the Paradox Basin are problems that require much

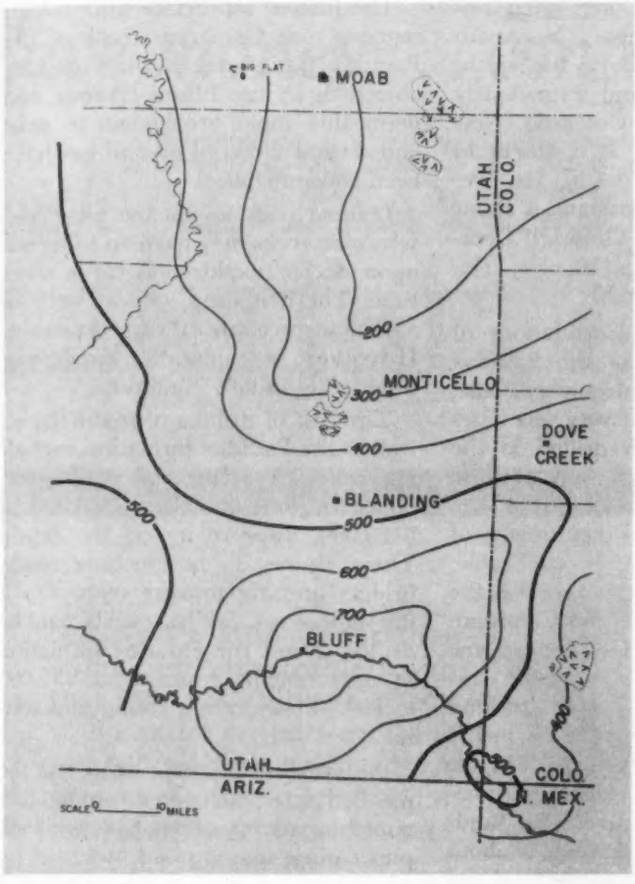

FIGURE 2—Generalized isopachous map of the Devonian system. Isopachous interval is 100 feet.

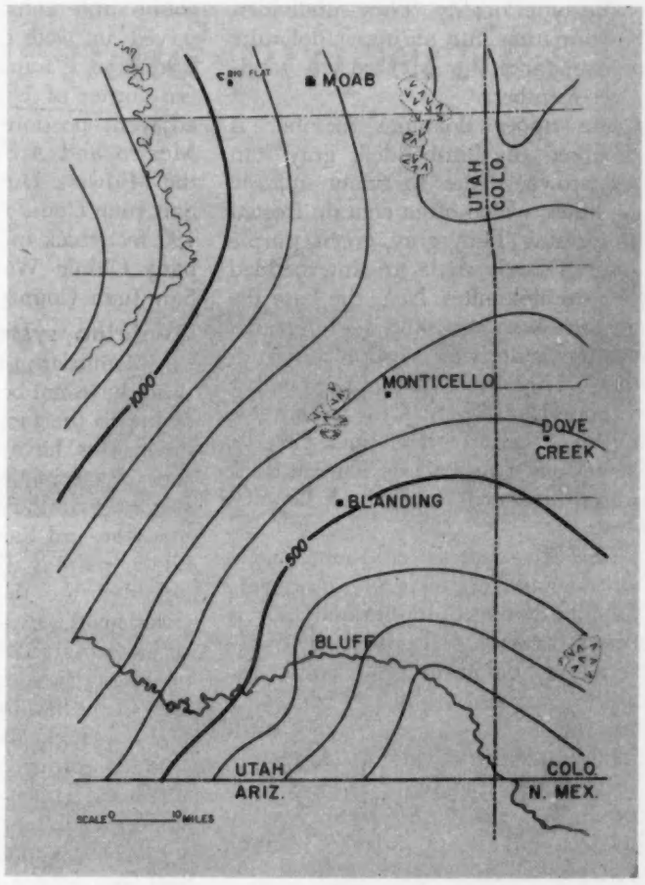

FIGURE 3—Generalized isopachous map of the Cambrian system. Isopachous interval is 100 feet.

additional study. Various names, such as Madison limestone, Deseret limestone, Humbug limestone, Great Blue limestone and Manning Canyon shale, have been applied to the Mississippian units of central Utah, whereas Madison limestone, Leadville limestone and Redwall limestone are used in the Four Corners area. A discussion of these problems is beyond the scope of this article—and therefore the term "Mississippian" will be used to designate the predominately carbonate section that lies between the Pennsylvanian Molas shale and the Upper Devonian Ouray limestone.

Examination of well cuttings has shown that the Mississippian of the Paradox Basin consists of an upper limestone and a lower dolomite section. These two subdivisions are good operational units for stratigraphic studies. The combined thickness of the two units ranges from about 200 feet to 600 feet in the Paradox Basin (Figure 1). Although subsurface control is still rather sparse, the Mississippian appears to become more dolomitic toward the north.

The upper unit consists of massive, white to buff and light brown limestones, which are finely to coarsely crystalline and fragmental. Locally, this unit becomes dolomitic and in part chalky. Thin dolomites and shales are interbedded with the limestones. Pre-Pennsylvanian erosion and weathering produced a Karst topography on the surface of the Mississippian. The unit ranges in thickness from about 35 feet at Coalbed Canyon (35s, 25e, San Juan County, Utah) to a little more than 300 feet in the Fish Creek area (38s, 20e, San Juan County, Utah).

The lower unit is primarily gray, buff, tan and brown, finely to coarsely crystalline dolomites. Some white to gray chert is generally found in the well cuttings in the upper part of the section. Traces of selenite and pyrite have also been observed in well cuttings. The dolomites become dolomitic limestones in places and interfinger with beds of limestone near the top of the unit. Locally, there are a few thin, light gray shales. The unit ranges in thickness from about 25 to 450 feet.

Devonian system. The nomenclature, age and correlation of the Devonian system of the Paradox are problems that remain to be solved. However, examination of well cuttings has shown that there are three operational units that are very useful in stratigraphic mapping. These are referred to as the Ouray limestone, the Elbert formation and the Aneth formation (in descending order). In this region the rocks that are assigned to the Devonian range in thickness from about 300 to 700 feet (Figure 2).

The Ouray limestone is made up of a succession of white, buff, gray and brown, dense and argillaceous limestones. A few thin, white, dolomitic beds and thin waxy, green shales with pyrite crystals are interbedded with the limestones. This formation disconformably underlies the dolomites of the lower Mississippian unit. The Ouray limestone thickens toward the northwest from about 35 feet in Township 40s, Range 26e, to about 175 feet in 34s, 19e, San Juan County, Utah.

Knight and Cooper[4] redefined the Elbert formation in the subsurface of the Paradox Basin and selected the Shell Oil Company Bluff Unit 1 (32, 29s, 22e, San Juan County, Utah)

as the type locality. They subdivided the formation into an upper dolomite member and the McCracken sandstone member.

The upper dolomite member is composed of thin-bedded, gray, tan and brown, dense to finely sucrosic dolomites, which often contain frosted sand grains. Thin, gray, green, purple and red sandy shale are interbedded with the dolomites. Near the base the member becomes sandy and grades into the underlying McCracken sandstone. The upper dolomite member is about 175 feet thick in the extreme northwest part of San Juan County, New Mexico, and about 325 feet thick in northwestern San Juan County, Utah.

The McCracken sandstone member is made up of white, gray and red, fine- to medium-grained, poorly sorted sandstones. Locally, the sandstones are dolomitic, glauconitic and argillaceous and are interbedded with red and green, silty shales and sandy dolomites. The member is absent in northwestern San Juan County, Utah, and is about 125 feet thick at East Boundary Butte in Apache County, Arizona.

The Aneth formation is a wholly subsurface stratigraphic unit, also defined by Knight and Cooper.[4] At its type locality (Shell Bluff Unit 1, 32, 39s, 22e, San Juan County, Utah) it is about 175 feet thick. The Aneth formation consists of dark brown to black, dense, resinous dolomites, which are interbedded with gray, brown and black shales and gray dolomites and siltstones. Pyrite, glauconite and anhydrite are often observed in well cuttings. The Aneth formation is found only in the southern corner of Utah and immediately adjacent portions of Colorado, New Mexico and Arizona. It is absent in the Midwest. Hughes 1 (30, 34s, 19e, San Juan County, Utah) and is about 190 feet thick in The Ohio Oil Company Chinle Wash 1 (10, 43s, 21e, San Juan County, Utah).

Cambrian system. Correlations of the Cambrian rocks of the Paradox Basin have not been adequately made, owing to the fact that very few basement tests have been drilled in the area. Examinations of well cuttings suggest that the nomenclature of the Stockton and Fairfield quadrangles of Utah (Gilluly 1932) is applicable, although the units may not be the exact age equivalents. The Cambrian rocks transgress time lines and become progressively younger toward the east. The Cambrian formations of Stockton and Fairfield quadrangles are (in descending order): Lynch dolomite, Bowman limestone, Hartman limestone, Ophir shale and Tintic sandstone. The Cambrian system is about 140 feet thick in the Continental Oil Company South Ute Mountain 1 (27, 32n, 20w, San Juan County, New Mexico) and about 980 feet thick in the Midwest Hughes 1 (30, 34s, 19e, San Juan County, Utah). In the Paradox Basin the Cambrian rocks range in thicknesss from less than 150 to more than 1,200 feet (Figure 3).

Conclusions. Detailed stratigraphic analyses of the pre-Pennsylvanian rocks of the Paradox Basin must await the drilling of additional basement tests. At this stage of development, however, it has become apparent that there are good reservoir rocks in the pre-Pennsylvanian section.

The discovery of commercial quantities of oil in the Mississippian at Big Flat has focused attention upon the carbonate reservoirs of this system. Good shows of oil, flammable gas and carbon dioxide have been encountered in the upper limestone and lower dolomite unit.

Porous and permeable carbonate and sandstone reservoirs are present in the Devonian. Carbon dioxide is produced from the Devonian at the McElmo field in Montezuma County, Colorado. Good shows of oil, flammable gas and carbon dioxide have been found in widely scattered tests that have penetrated the Devonian in the Paradox Basin.

The limited subsurface information suggests that Cambrian rocks of the Paradox Basin may become drilling objectives in the future. Porous and permeable zones are known to exist and several shows of oil and gas have been encountered.

Drilling costs to test the pre-Pennsylvanian rocks may have an influence upon deeper exploration for a short time. The first deep wildcat wells in a remote area are always expensive. However, as exploration progresses, these costs usually diminish.

The cost of drilling a producing oil well to the Paradox formation, including coring, testing and equipment, now ranges from about $80,000 to $125,000, depending on the depth. These figures do not include roads, bridges and rig moving costs. On a dry hole basis, wildcat wells can be drilled to test the Paradox formation at costs ranging from about $50,000 to $90,000, including coring and testing.

An estimate of the cost to test the pre-Pennsylvanian zones can be prepared by adding about $12 per foot, plus coring, testing, road building, rig moving, etc. For a completed oil well an additional $4 per foot will be required. It is estimated that some deep basement tests will cost in the vicinity of $1 million. Some operators now believe that Mississippian wells can be completed for about $200,000 in the more accessible parts of the region.

It is currently impossible to make any statements concerning reserves and reservoir performances. It is, however, reasonable to assume that the Mississippian reserves will be essentially similar to those of other Mississippian carbonate reservoirs of the Rocky Mountain region, for the carbonate rocks of this system possess remarkably similar lithologic characteristics throughout a vast area.

REFERENCES

1. Clair, J. R. (1952) Paleozoic Rocks of the Southern Paradox Basin; Four Corner Geol. Soc. Guidebook, pp. 36-39.
2. Cooper, J. C. (1955) Cambrian, Devonian and Mississippian Rocks of the Four Corner Area; Four Corner Geol. Soc. Guidebook, pp. 59-65.
3. Gilluly, James (1932) Geology and Ore deposits of the Stockton and Fairfield Quadrangles, Utah; U. S. Geol. Survey, Prof. Paper 173.
4. Knight, R. L. and Cooper, J. C. (1955) Suggested Changes in Devonian Terminology; Four Corners Geol. Soc. Guidebook.
5. Lockman-Balk, Christina (1956) Cambrian Stratigraphy of Eastern Utah; Intermountain Assoc. Petrol. Geol. Guidebook, Seventh Ann. Field Conf., pp. 58-64.
6. Sadlick, Walter (1956) Some Upper Devonian-Mississippian Problems in Eastern Utah; Intermountain Assoc. Petrol. Geol. Guidebook, Seventh Ann. Field Conf., pp. 65-76.
7. Wells, L. F. (1954) Stratigraphic Correlations of Central and South-Central Utah; Intermountain Assoc. Petrol. Geol. Guidebook Fifth Ann. Field Conf., pp. 15-17.

About the Author

Dr. Carl A. Moritz, chief geologist. for Alex W. McCoy Associates, Inc., Tulsa, holds a B.A. degree in geology from the University of Kansas and M.A. and Ph.D. degrees from Harvard University. In the past he has been a geologist with The National Lead Company, Union Mines Development Corp., Phillips Petroleum Co. and Gulf Oil Corp. He also taught geology at the University of Tennessee and Dartmouth College.

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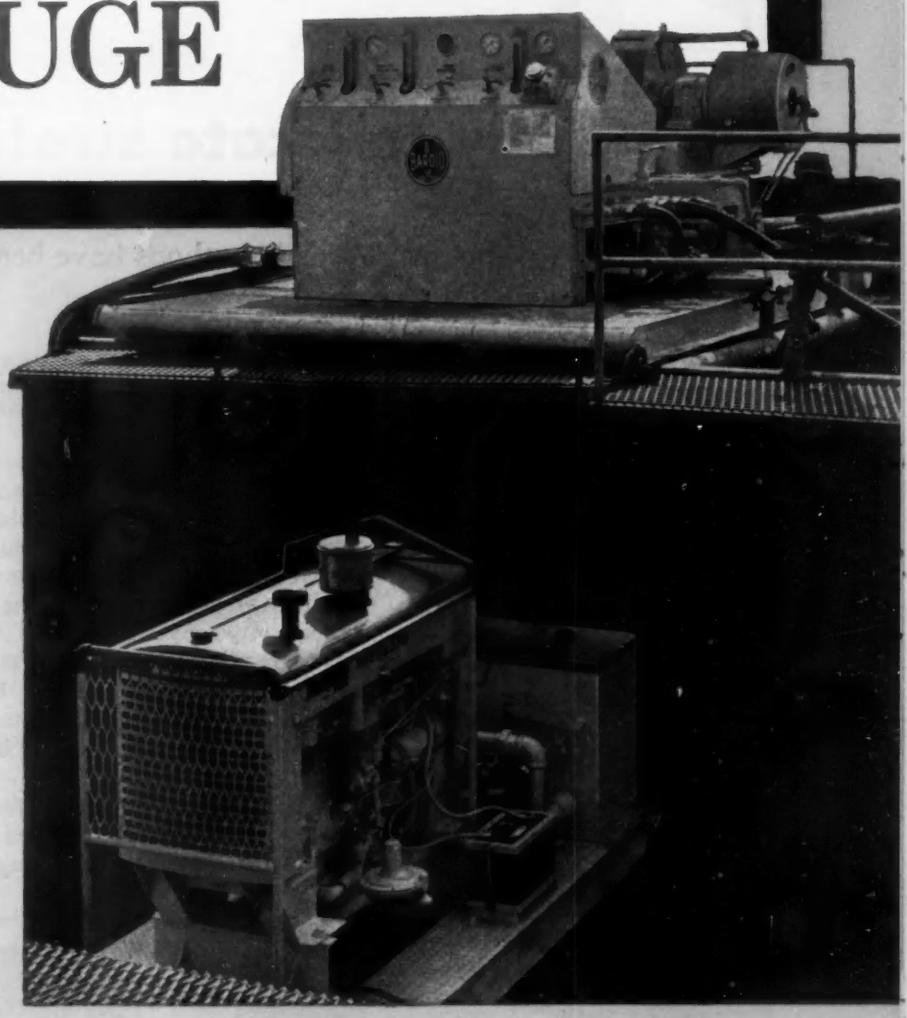

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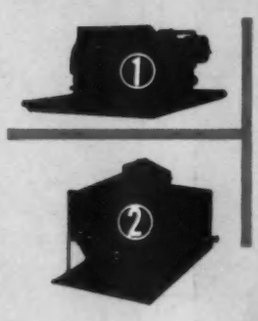

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as the type locality. They subdivided the formation into an upper dolomite member and the McCracken sandstone member.

The upper dolomite member is composed of thin-bedded, gray, tan and brown, dense to finely sucrosic dolomites, which often contain frosted sand grains. Thin, gray, green, purple and red sandy shale are interbedded with the dolomites. Near the base the member becomes sandy and grades into the underlying McCracken sandstone. The upper dolomite member is about 175 feet thick in the extreme northwest part of San Juan County, New Mexico, and about 325 feet thick in northwestern San Juan County, Utah.

The McCracken sandstone member is made up of white, gray and red, fine- to medium-grained, poorly sorted sandstones. Locally, the sandstones are dolomitic, glauconitic and argillaceous and are interbedded with red and green, silty shales and sandy dolomites. The member is absent in northwestern San Juan County, Utah, and is about 125 feet thick at East Boundary Butte in Apache County, Arizona.

The Aneth formation is a wholly subsurface stratigraphic unit, also defined by Knight and Cooper.[4] At its type locality (Shell Bluff Unit 1, 32, 39s, 22e, San Juan County, Utah) it is about 175 feet thick. The Aneth formation consists of dark brown to black, dense, resinous dolomites, which are interbedded with gray, brown and black shales and gray dolomites and siltstones. Pyrite, glauconite and anhydrite are often observed in well cuttings. The Aneth formation is found only in the southern corner of Utah and immediately adjacent portions of Colorado, New Mexico and Arizona. It is absent in the Midwest. Hughes 1 (30, 34s, 19e, San Juan County, Utah) and is about 190 feet thick in The Ohio Oil Company Chinle Wash 1 (10, 43s, 21e, San Juan County, Utah).

Cambrian system. Correlations of the Cambrian rocks of the Paradox Basin have not been adequately made, owing to the fact that very few basement tests have been drilled in the area. Examinations of well cuttings suggest that the nomenclature of the Stockton and Fairfield quadrangles of Utah (Gilluly 1932) is applicable, although the units may not be the exact age equivalents. The Cambrian rocks transgress time lines and become progressively younger toward the east. The Cambrian formations of Stockton and Fairfield quadrangles are (in descending order): Lynch dolomite, Bowman limestone, Hartman limestone, Ophir shale and Tintic sandstone. The Cambrian system is about 140 feet thick in the Continental Oil Company South Ute Mountain 1 (27, 32n, 20w, San Juan County, New Mexico) and about 980 feet thick in the Midwest Hughes 1 (30, 34s, 19e, San Juan County, Utah). In the Paradox Basin the Cambrian rocks range in thicknesss from less than 150 to more than 1,200 feet (Figure 3).

Conclusions. Detailed stratigraphic analyses of the pre-Pennsylvanian rocks of the Paradox Basin must await the drilling of additional basement tests. At this stage of development, however, it has become apparent that there are good reservoir rocks in the pre-Pennsylvanian section.

The discovery of commercial quantities of oil in the Mississippian at Big Flat has focused attention upon the carbonate reservoirs of this system. Good shows of oil, flammable gas and carbon dioxide have been encountered in the upper limestone and lower dolomite unit.

Porous and permeable carbonate and sandstone reservoirs are present in the Devonian. Carbon dioxide is produced from the Devonian at the McElmo field in Montezuma County, Colorado. Good shows of oil, flammable gas and carbon dioxide have been found in widely scattered tests that have penetrated the Devonian in the Paradox Basin.

The limited subsurface information suggests that Cambrian rocks of the Paradox Basin may become drilling objectives in the future. Porous and permeable zones are known to exist and several shows of oil and gas have been encountered.

Drilling costs to test the pre-Pennsylvanian rocks may have an influence upon deeper exploration for a short time. The first deep wildcat wells in a remote area are always expensive. However, as exploration progresses, these costs usually diminish.

The cost of drilling a producing oil well to the Paradox formation, including coring, testing and equipment, now ranges from about $80,000 to $125,000, depending on the depth. These figures do not include roads, bridges and rig moving costs. On a dry hole basis, wildcat wells can be drilled to test the Paradox formation at costs ranging from about $50,000 to $90,000, including coring and testing.

An estimate of the cost to test the pre-Pennsylvanian zones can be prepared by adding about $12 per foot, plus coring, testing, road building, rig moving, etc. For a completed oil well an additional $4 per foot will be required. It is estimated that some deep basement tests will cost in the vicinity of $1 million. Some operators now believe that Mississippian wells can be completed for about $200,000 in the more accessible parts of the region.

It is currently impossible to make any statements concerning reserves and reservoir performances. It is, however, reasonable to assume that the Mississippian reserves will be essentially similar to those of other Mississippian carbonate reservoirs of the Rocky Mountain region, for the carbonate rocks of this system possess remarkably similar lithologic characteristics throughout a vast area.

REFERENCES

1. Clair, J. R. (1952) Paleozoic Rocks of the Southern Paradox Basin; Four Corner Geol. Soc. Guidebook, pp. 36-39.
2. Cooper, J. C. (1955) Cambrian, Devonian and Mississippian Rocks of the Four Corner Area; Four Corner Geol. Soc. Guidebook, pp. 59-65.
3. Gilluly, James (1932) Geology and Ore deposits of the Stockton and Fairfield Quadrangles, Utah; U. S. Geol. Survey, Prof. Paper 173.
4. Knight, R. L. and Cooper, J. C. (1955) Suggested Changes in Devonian Terminology; Four Corners Geol. Soc. Guidebook.
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6. Sadlick, Walter (1956) Some Upper Devonian-Mississippian Problems in Eastern Utah; Intermountain Assoc. Petrol. Geol. Guidebook, Seventh Ann. Field Conf., pp. 65-76.
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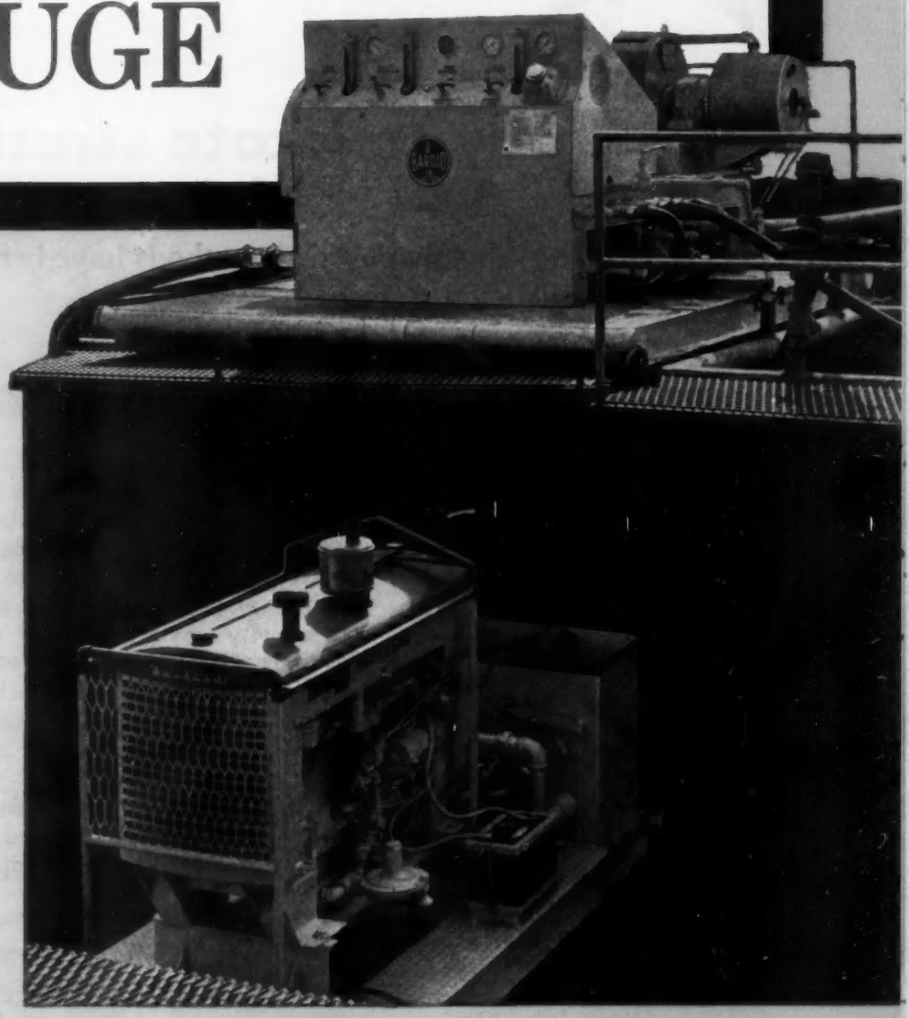

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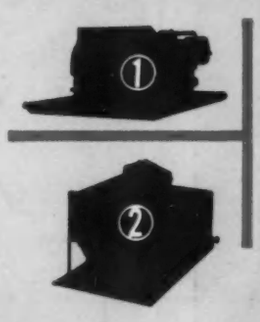

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New way to locate stratigraphic traps

These radio-geophysical methods have been used with accuracy where other methods have failed.

By Donald W. Slattery
Slattery Geophysical Service, Loveland, Colo.

TWO RECENT radio-geophysical methods have been developed that show great promise in mapping not only the conventional type structure but also the stratigraphic trap. A high degree of accuracy is obtained with these methods at a reasonable cost. The methods have proven to be useful in areas where other systems have provided questionable data.

Most geologists agree that the major untapped reserves of oil in the U. S. are in stratigraphic traps. The big question: how can we find them? Much exploration progress has been made through subsurface geological studies, geochemical methods, improved seismographic instrumentation and interpretation techniques and radioactivity surveys. None of these is a cure-all, and each has serious shortcomings, the most serious being the very low success ratios obtained. High costs are an added factor in the case of the seismograph.

The detection and mapping of fields with the systems described here are not dependent upon the mapping of structure. Rather it is because underground oil or gas accumulations are invariably accompanied by secondary or side effects which can be mapped by these radio methods. One of these factors is that every oil and gas field is surrounded with a belt or halo of secondary mineralization of geochemical origin. This mineralization halo can be detected by various means including chemical, electrical and radioactivity. Soil alterations due to leaching, erosion and re-working of the sediments seriously affect this sur-

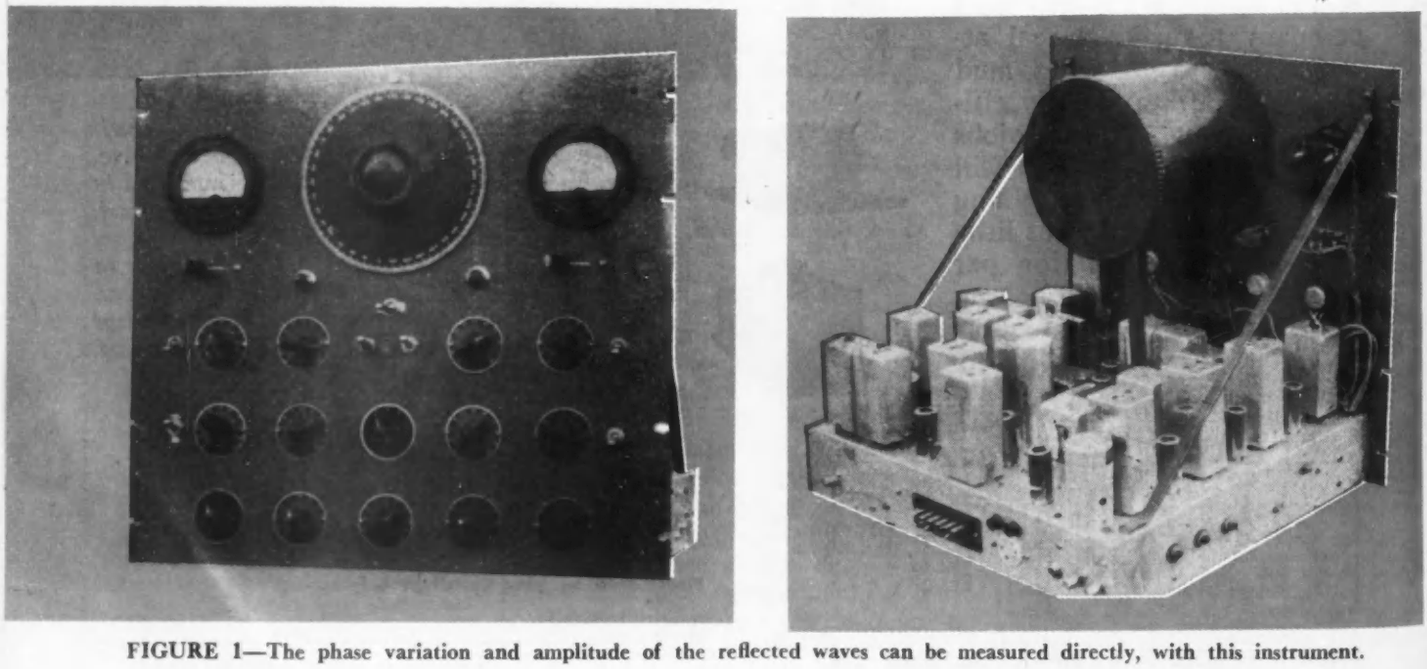


FIGURE 1—The phase variation and amplitude of the reflected waves can be measured directly, with this instrument.

face pattern. Consequently, the detection and mapping of it by radioactivity or chemical means is a very uncertain proposition. Electrical resistivity measurements also are not dependable because of the effect of near surface factors, such as water which seriously alters the resistivity measurements. To offset the limitations of the foregoing, new radio-induction equipment was developed.

Measurements of the relative electrical conductivities of the earth to a considerable depth is easily accomplished with this equipment. Surface and near surface water streams and lakes have virtually no effect on the results. Successful surveys have been conducted under the most adverse circumstances including river bottoms of such rivers as the Ohio and the Wabash. Obviously, the penetration is great enough to pick up the secondary mineralization halo which is present in the formations under the water bearing sands and gravels. In like manner, successful surveys have been conducted in the Nebraska sandhills where the depth of the sand overburden was known to be several hundred feet. The present day induction equipment is a vast improvement over its predecessors through the use of new inventions, but even so, many oil fields were discovered with equipment of the original design.

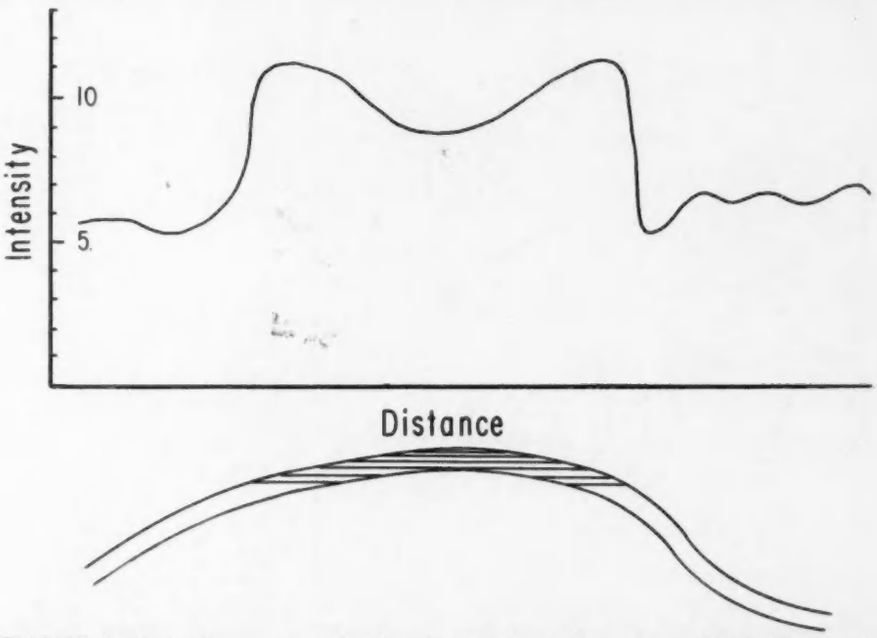


FIGURE 2—Induction surveys, showing the usual pattern across a field is illustrated. Upward deviations are significant and can be indicative of faulting or of oil or gas accumulation. As a rule, degree of upward change is indicative of quality of the prospect.

Induction surveys are most generally conducted by running profiles across the area to be investigated. The usual pattern across a field is illustrated in Figure 2. Notice that the readings at the edge of the field take a sharp upward rise and then taper

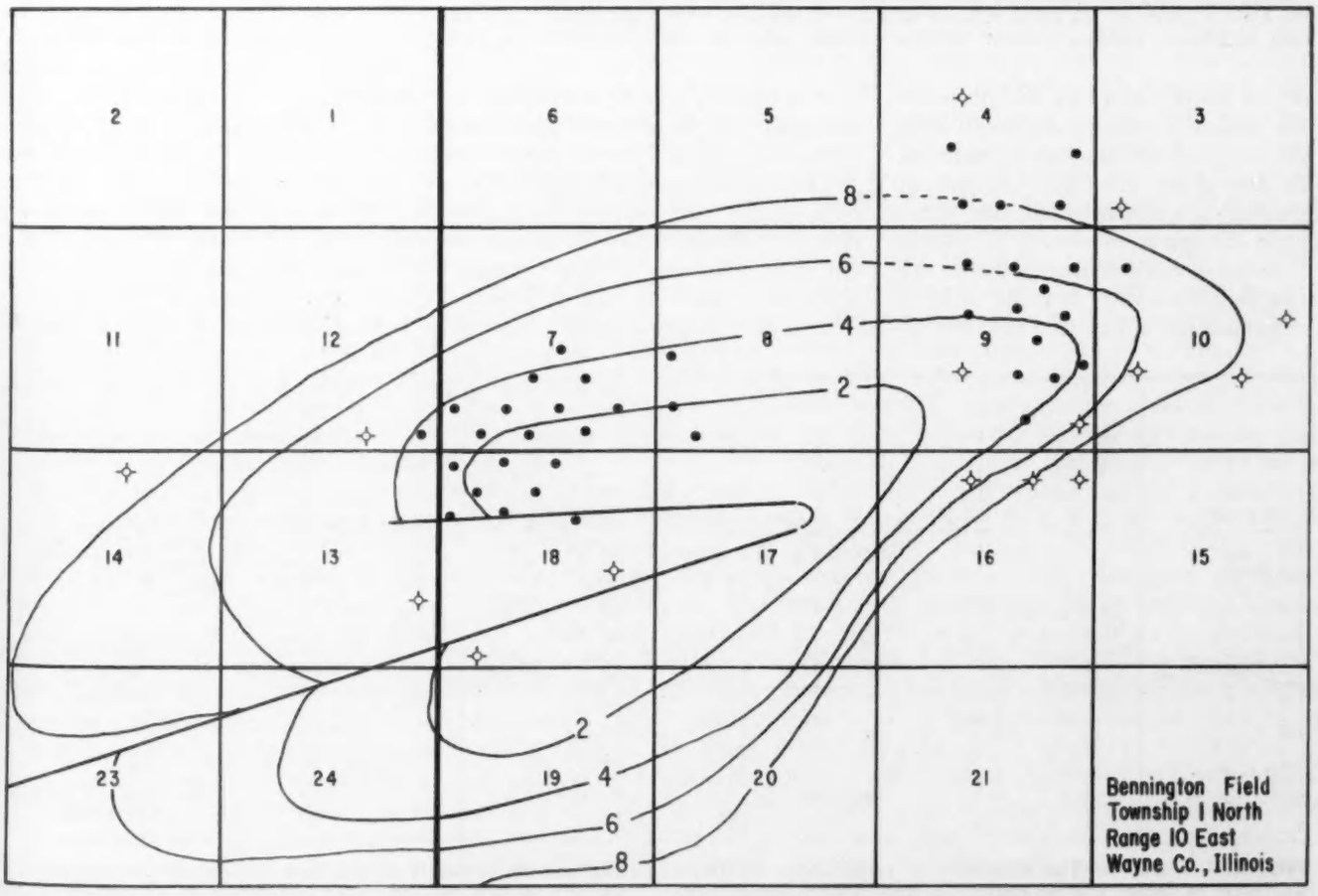


FIGURE 3—The Bennington field, considered a stratigraphic trap with no structural closure, was discovered in 1942 with the induction system. Numerous geophysical surveys including seismograph and magnetometer repeatedly condemned the field.

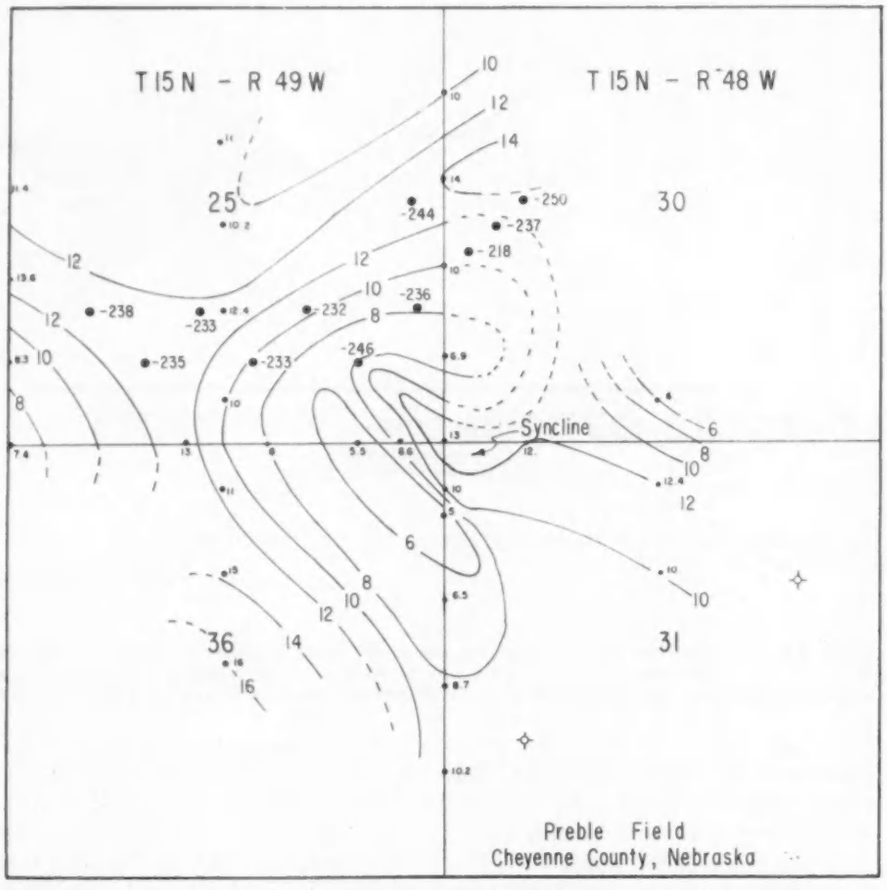


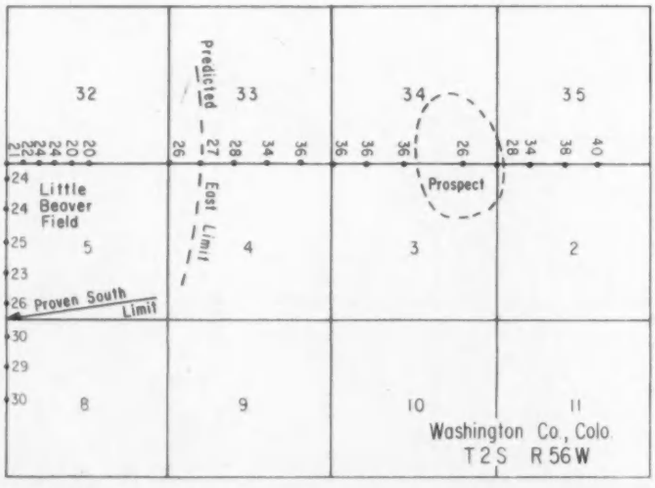
FIGURE 4—The Preble pool, Cheyenne County, Nebraska, was discovered several months after this induction survey in 1952. Locations of the well sites and elevations of the Dakota sandstone on each, reduced to sea level, are shown for comparison. Considerable agreement appears evident between drilling data and the mineralization halo.

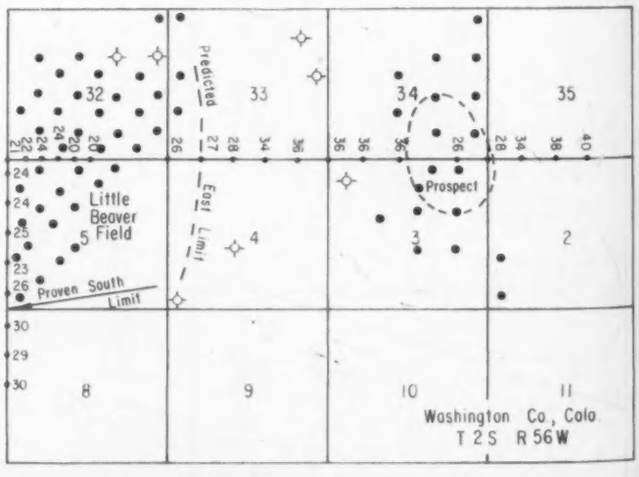
off to lower values in the center of the pool in a manner similar to usual geochemical or radioactivity patterns. In any given area, the background reading is quite constant and shows little change from station to station. Upward deviations are significant and can be indicative of faulting or of oil or gas accumulation. As a rule, the degree of upward change is indicative of the quality of the prospect. Significant changes are usually two to three times the normal background reading but a hard or fast rule can not be set. The degree of change is somewhat dependent upon the area. Figures 3 and 4 show how this works out in practice. These are maps of fields surveyed prior to their discovery with the induction system of exploration.

Figure 3 is a map of the Bennington field in Wayne and Edwards counties, Illinois, at an early stage of development. This field was discovered in a survey conducted in 1942. It was condemned repeatedly by numerous geophysical surveys including seismograph and magnetometer. Those who have been closely connected with the field regard it as a stratigraphic trap with virtually no structural closure. The normal background reading on this area was 3.0. Accordingly, the contrast ratio was approximately three to one. This would identify the prospect as very favorable.

Figure 4 shows a map of a survey run in Cheyenne County, Nebraska, in the spring of 1952. The normal background reading in that area was 6.5. The relative conductivity values on this structure ranged upward to more than twice this amount. Accordingly, this was a favorable prospect. It was drilled about two to three months after the survey, and this resulted in the discovery of the Preble pool. Locations of the well sites and elevations of the Dakota sandstone on each, reduced to sea level, are shown for comparison. It is evident that there is a considerable degree of agreement between the drilling data and the mineralization halo. Another factor of importance is that these readings will repeat now or ten years from now. If desirable, the survey could be continued from the place it was originally stopped without going over previous work.

In 1952, when engaged in mapping





FIGURES 5 and 6—The reflection or re-radiation technique was used to locate this stratigraphic trap, Little Beaver field, Washington County, Colorado. Prior to the survey, production was limited to a small area along the east line of section six. The eastern boundary of the field was accurately established in advance of drilling and two other prospects were revealed, the East Little Beaver field and the Bob Cat field. These were later drilled to confirm the prediction as shown in Figure 6.

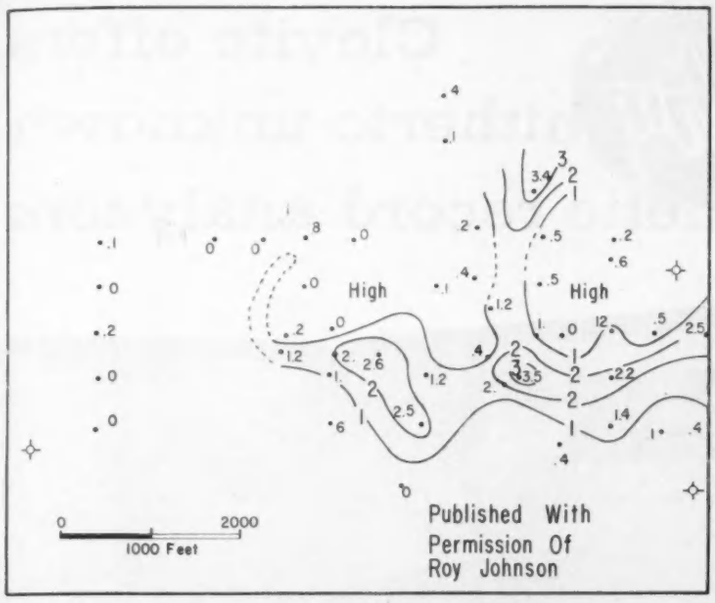


FIGURE 7—Based on seismographic information, several dry holes were drilled on this structure in Oklahoma, originally mapped with the induction system. Reflected wave data shows a pinch-out on the flanks of the anticline. In view of good shows in both wells and this survey, indications are that production could be established between these wells. Very low conductivity readings on the crest of the structure indicate locations drilled there would be dry.

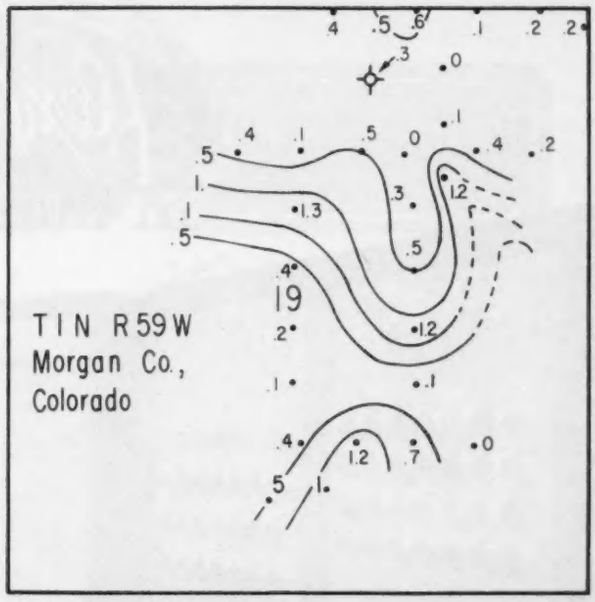


FIGURE 8—This reflected survey was run several years after the dry hole was drilled on a major company farm-out seismograph prospect. The survey shows the dry hole to be off structure with a reflected wave reading of 0.3. The location should have been farther south within the belt of favorable readings, as the nearby Park field gave readings on good production of 1.0.

reef highs near Edmonton, Alberta, utilizing newly developed induction equipment, an interference phenomenon was observed which led to the discovery of a new method of geophysical exploration. Its operation is apparently dependent upon the electrical insulating quality of the oil. This method has proven to be extremely reliable and valuable in the mapping of structures especially stratigraphic traps. From experimental work with the system, it is obvious that radio waves which are propagated into the ground are re-radiated or reflected to the surface. Just why this occurs is not positively known. Several possible explanations can be found in geophysical literature and in geophysical patents. Both explanations depend upon the electrical resistivity contrast or interface between the oil or gas bearing formations and the surrounding formations which may or may not carry salt water. Whatever the cause, the fact remains that a wave does return to the surface after reflection or re-radiation from oil deposits and that the strength of this wave is closely related to the quantity of oil present at that spot. If the sandstones or limestones carry oil in small and insignificant quantities, a very weak and perhaps undetectable or unmeasurable signal will be reflected to the surface. If the sands are thick and well saturated, relatively strong waves will be returned to the surface. By contouring these variations in signal strength, the oil field can be accurately contoured and the points where the best wells will be secured can be determined in advance of drilling.

The original reflection or re-radiation technique was vastly inferior to the present day techniques, but even so, it proved to be extremely accurate. It was thoroughly tested on the reef highs in the Edmonton area so as to find how the new technique could be used most effectively. It was later tried on a stratigraphic trap in the newly discovered Little Beaver field of Washington County, Colorado. The results are presented in Figures 5 and 6. This particular area had been repeatedly seismographed with negative results. At the time that the survey was run, the spring of 1953, the size and extent of the field was unknown. Production was limited to a small area along the east line of Section 6, and one well was being drilled in Section 5. The results of this survey were published in May, 1953, to prove that stratigraphic traps could be successfully located and outlined with radio methods. Not only was the eastern boundary of the field accurately established in advance of drilling, but the presence of several other unsuspected oil fields was also revealed. One is shown on this map. Several years later, a major company discovered and developed the new "East Little Beaver Field." Another of these prospects, "the Bob Cat Field," was discovered later. The accuracy of the prediction was thus established. In that area, the original reflected wave survey gave instrument readings that were not a true measure of the amplitude of the reflected wave but which were approximately inversely proportional to it. Consequently on this particular survey, better oil prospects were indicated with a decreased reading and increased reflection wave amplitude.

Since this reflected wave technique was developed, great changes have been made in the equipment. Today's measuring apparatus is a very complex instrument containing 32 tubes. Note the photographs in Figure 1. With this new equipment, the phase variations and amplitudes of the reflected waves can be measured directly.

Normally, the amplitude of the reflected wave away from oil deposits is zero and the reading rises when oil or gas is present underground in quantity. Unfortunately, since this is a newly developed method, very few maps can be released showing the results of surveys with this new method. A number of new fields have been located with it. Enough work has been done with the method in areas where other geophysical methods gave poor results or failed completely to establish beyond question

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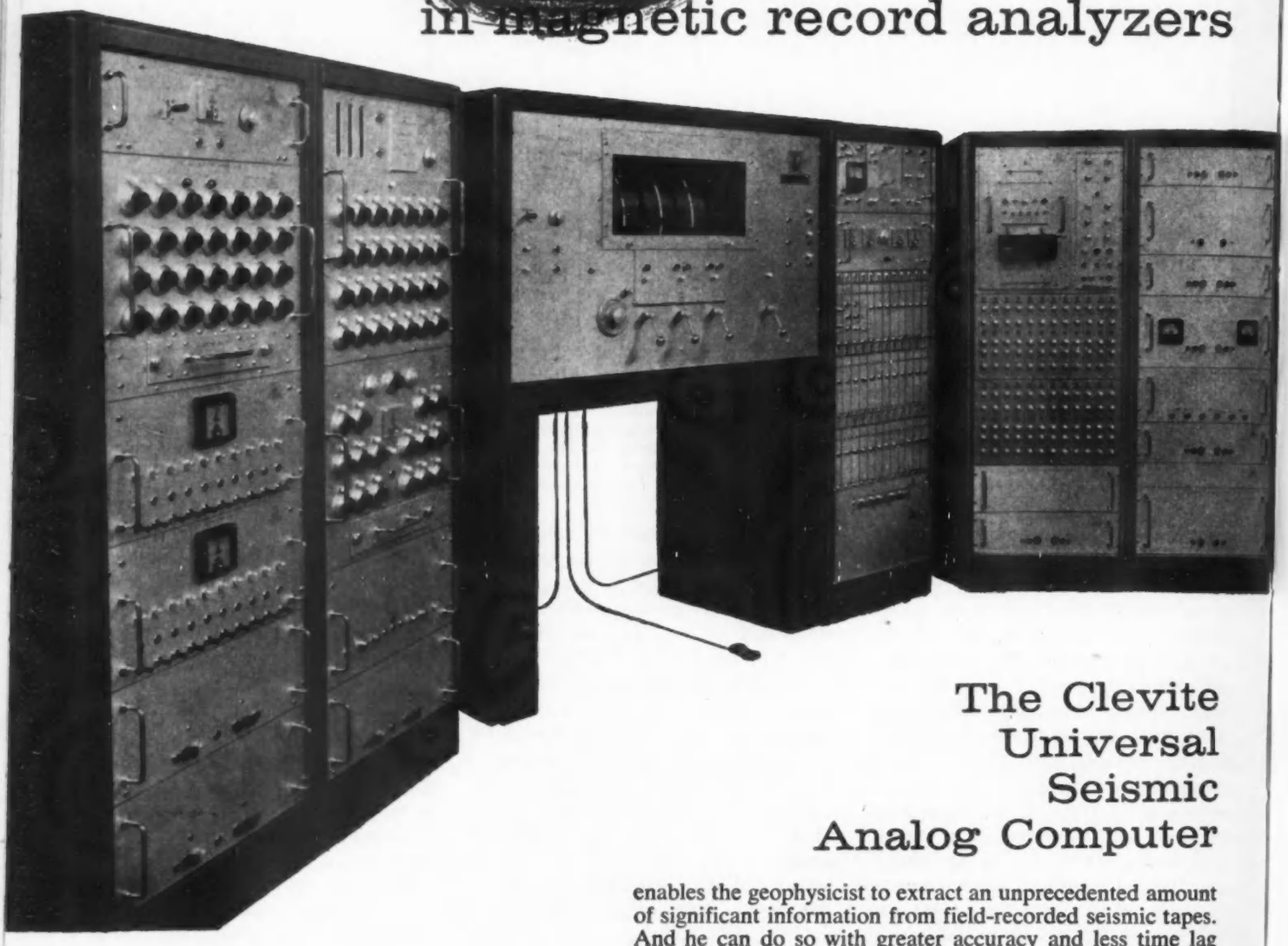

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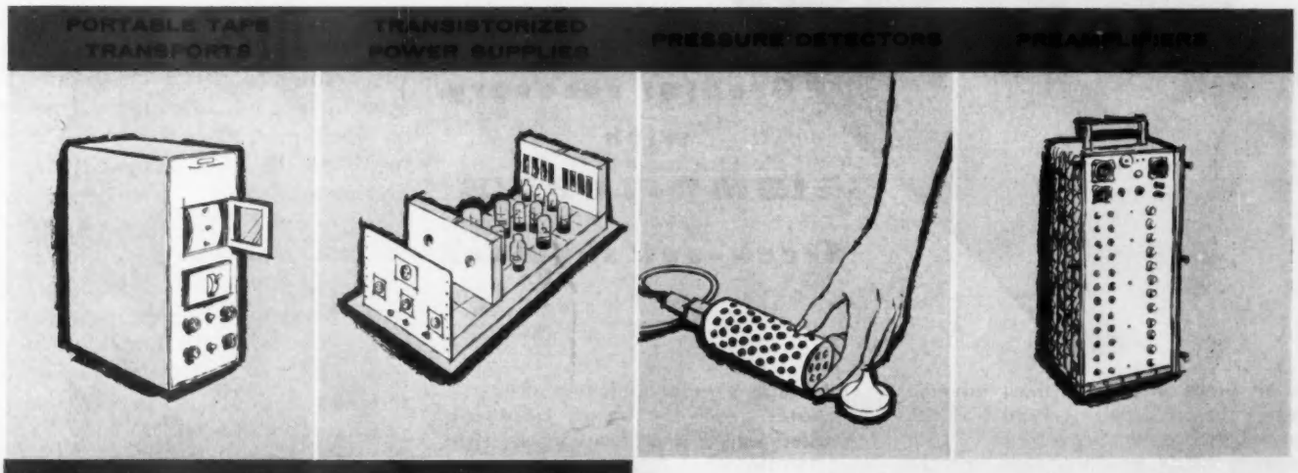

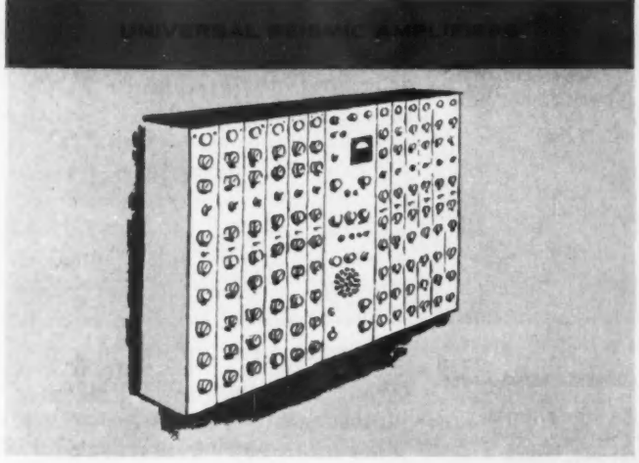

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that it is a very valuable development. It can be used either alone or supplement advantageously other geophysical systems. It has proven to be particularly valuable in the mapping of stratigraphic traps.

A structure in Oklahoma, the whereabouts of which cannot be revealed at this time is shown in Figure 7. This structure was originally mapped with the induction system. Several dry holes were drilled, based on seismographic information. Recently, reflected wave survey data showed that the potentially oil productive sandstone was pinched out on the flanks of the anticline. Logs of the two dry holes revealed oil showings in both, one indicating very thin, pinched out sandstones and the other having good showings, enough that pipe was very nearly set on it. Obviously between these wells, there is an oil field. The very low readings obtained at the crest of the structure should be brought to the attention of the reader. This is clear-cut evidence that any well drilled at the crest of the structure is certain to be a duster.

The Denver Basin is the one place where most wells are considered wildcats, even in proven oil fields because of the sand lensing condition encountered in the Dakota sandstone. Many a dry hole has been drilled directly between two producers. This newly developed reflected wave system works exceedingly well in this area, as sand lenses can be easily mapped with it. It has been demonstrated repeatedly that prospects which appear favorable with other geophysical methods will show up their true colors with this method. Numerous examples could be cited but only one will be used. Figure 8 is a reflected wave survey of a major company seismographic prospect in Morgan County, Colorado, which was drilled as a farm-out. The survey was run several years after the well was drilled. So far, there has not been any drilling to test the accuracy of the survey results. The reflected wave reading at the well site was .3 which is indicative that the well had non-commercial oil showings. A check with the land owner verified this. Furthermore, a check of the cores found lying near the well showed that the sandstone was tight and hard but that they still had a good strong crude oil odor after being exposed in the open air for two years. The results of the survey revealed that the well was not favorably located. The location should have been farther south to be within the belt of favorable readings. A profile run across production on the nearby Park field gave instrument readings on good production of 1.0. Accordingly, on this prospect, wells drilled on properly situated well sites should have an excellent chance of producing commercially.

Ordinarily, on geophysical surveys with this equipment, the preliminary profiles are run with induction equipment. This equipment is by far the most rapid and the best means of examining a property quickly for oil or gas prospects. After locating oil or gas prospects with the induction system, profiles are then run with the reflection system. If favorable results are obtained, detail work can then be carried out. However if results are not obtained with the reflected wave system, it is useless to proceed further with that prospect in that vicinity for it will not contain oil in commercial quantites.

Recent developments in equipment and techniques for use in reflected wave surveys have great promise. One of these developments is the use of phase measurements on reflected wave.

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Statistically speaking, the results of induction surveys alone, which are based upon mineralization halos, can be expected to run about 50 percent correct in the prediction of commercial production on wildcat wells. The writer believes that the success ratio percentage of wells based on reflected radio wave data will run much higher than this but statistical proof is lacking. It will be necessary to wait until enough data is collected from wildcat wells drilled on reflected wave data to know just how reliable the system really is. However, every wildcat well that has been drilled on structures condemned by either system has been a duster. These new methods will make possible the economical exploration of such places as the Edward's Plateau and the Delaware Basin where the best seismographic systems give very questionable data.

Enabling the operator to reduce his dry wildcat locations can be of great value alone, to say nothing of his increased opportunity to make some worthwhile oil or gas strikes. In these days of stiff proration and increasing costs, the operator is caught in an economic squeeze. Unless he can find oil more efficiently, he is very likely to be forced out of the business.

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Magnetic Tape

Continued from Page 122

and measurements. A report by the Sub-Committee on Definitions and Measurements of the SEG Committees on Magnetic Recording has been published (October, 1957, *Geophysics*). This report proposed definitions and standards applicable specifically to recording equipment designed for seismic use. It also suggests measurement and reporting procedures that will provide data and information to facilitate the accurate evaluation of magnetic equipment. These standards with such modifications as may be suggested by the industry could be a common means of evaluating the many different types of equipment available.

It appears that it will be impossible to standardize field recorders in the foreseeable future. Initially, the tape recorder manufacturers made no attempt to standardize, and now the purchasers will not allow standardization.

Playback systems are a completely different problem. Whereas a certain amount of standardization would be desirable in field recorders, the playback machines need only be able to accept the field tape dimensions and no other standardization is necessary or desirable. A variety of different presentations can be made, each having a definite place as an aid to interpretation.

Although a certain limited degree of standardization would be desirable, it is perhaps fortunate that there was little standardization in the beginning of field recorder and playback equipment design. The industry has been allowed to look at all available systems thus far devised, and there have been few limitations as to the types of recorders available. There have been no undesirable limitations placed on the potential versatility of the systems. Even if attempts had been made to standardize, undoubtedly many machines would have been requested by the purchasers that would not maintain the standards originally set up. New manufacturers entering the field will probably pattern their drum size and head spacing after some of the more widely used machines now in operation. Eventually, one or two types of field recorders may account for 80 or 90 percent of all field tape systems.

—**The End**

Higher strength casing for bottom-hole pressures of 15,000 psi

Stronger casing permits longer protection strings to be set. This new casing is capable of withstanding higher pressures and increased stresses of deeper drilling.

By Sheldon H. Reynolds, National Tube Division, United States Steel Corporation, Houston

A NEW WELL casing has been developed with a minimum yield strength of 150,000 pounds per square inch. This strength imparts tension values to existing non-upset threaded connections which are designed to permit longer strings to be set. Also, the use of high grade steel and buttress threads in the heavier weights would permit large long protection strings, thereby allowiing the use of large bits at greater depths. Large drill pipe with its improved hydraulics can be used.

The current API-5A specification shows a Grade P-110 casing. One of the methods used in the manufacture of casing that lead to this grade was the development of deep-well casing from water spray quenching and tempering of carbon steels in long tubular form. Use of this method on carbon steels imparts high yield strength and toughness while maintaining high ductility.

The same method used on mild alloy steel analyses, results in still higher strengths. A casing tentatively designated V-150 has been produced and used in the oil fields. V-150 casing at minimum yield strengths of 150,000 psi at 0.7 percent total strain is accompanied by average ultimate strengths of 171,000 psi and average elongations of 19 percent in 2 inches.

Table 1 shows the tentative performance properties for use in designing strings of V-150 casing along with similar properties of P-110 as a basis of comparison. Table 2 covers the minimum collapse resistance under axial tension stress used in multiple weight casing string design for V-150 casing. A study of these tables reveals that almost a 20 percent gain is developed in joint strengths of the API Long T and C connection. In the proper weights wherein elastic collapse is not a factor, V-150 develops approximately 32.5 percent more resistance to collapse pressures than does P-110. Considering minimum internal yield pressures, V-150 is more than 36 percent stronger than P-110.

As a means of making a practical comparison, 14,000-foot long strings A, B and C are shown in 7-inch O.D. These are designed for 16 ppg mud (120 pounds per cubic foot) to safety factors of 1⅛ in collapse, 2 in tension, 1.5 in tension yield strength and 1 in internal yield pressures using the method of A. C. Temmel.[1] It is not the intention to recommend safety factors but rather to show designs to assume safety factors in the interest of making comparisons.

The A string is confined to P-110 and uses the buttress thread connection on top. It requires the use of 38 pound-per-foot casing with a restricted drift diameter of 5.795 inches which limits drilling below this string to a 5¾-inch bit. The string weighs 461,350 pounds.

The B string substitutes 32-pound casing V-150 for the bottom two items of tne heavier P-110, and results in a constant weight string confined to 32-pound casing with a minimum drift diameter of 5.969 inches which permits the passage of the next larger bit size of 5⅞ inches. This would be an advantage if drilling is to be conducted below the 7-inch cas-

Tables on Pages 154-155. Text Continued on Page 164.

TABLE 1—Casing—API Grade P-110 and Tentative Grade V-150

(Furnished with Long Threads and Couplings)

COLLAPSE AND TENSION PROPERTIES

Size: Outside Diameter	Nominal: Weight Per Foot Threads and Coupling	Steel Grade	MINIMUM PROPERTIES							[1]Plain End Yield Strength (min.)
				TENSION						
				API		BUTTRESS[1]				
								SPEC CLEARANCE		
			Collapse Pressure	Equiv Length S.F. 2	Ult. Joint Strg.	Equiv Length S.F. 2	Ult. Joint Strg.	Equiv Length S.F. 2	Ult. Joint Strg.	
Ins.	Lbs.		psi	Feet	1000 Lbs.	Feet	1000 Lbs.	Feet	1000 Lbs.	1000 Lbs.
5	15.00	P	9430	12570	377	18670	560	16800	504	481
	18.00	P	12390	12860	463	18750	675	14670	528	580
	15.00	V	11010	14930	448	22970	689	17600	528	656
	18.00	V	16420	15310	551	23080	831	14670	528	791
5½	17.00	P	8520	12290	418	18590	632	16740	569	546
	20.00	P	10910	12500	500	18550	742	14520	581	641
	23.00	P	12870	12520	576	18370	845	12630	581	729
	20.00	V	14460	14880	595	22580	903	14520	581	874
	23.00	V	17060	14910	686	19630	903	12630	581	994
7	26.00	P	7220	11580	602	18210	947	14620	760	831
	29.00	P	9220	11740	681	18280	1060	13100	760	930
	32.00	P	10700	11810	756	18270	1169	11880	760	1024
	35.00	P	12180	11870	831	18230	1276	10860	760	1119
	38.00	P	13130	11840	900	17860	1357	10000	760	1206
	29.00	V	10480	13970	810	22480	1304	13100	760	1267
	32.00	V	14180	14060	900	21200	1357	11880	760	1398
	35.00	V	16150	14130	989	19390	1357	10860	760	1526
	38.00	V	17410	14080	1070	17860	1357	10000	760	1644
7⅝	29.70	P	6180	11130	661	17910	1064	16130	958	939
	33.70	P	8780	11280	760	17970	1211	15710	1059	1070
	39.00	P	10900	11350	885	17880	1395	13580	1059	1231
	33.70	V	9460	13430	905	22110	1490	15710	1059	1458
	39.00	V	14440	13500	1053	22000	1716	13580	1059	1679
	45.30[1]	V	17590	13790	1249	21270	1927	11690	1059	1971
9⅝	43.50	P	4760	10060	875	17620	1533	15150	1318	1381
	47.00	P	6120	10130	952	17620	1656	14020	1318	1493
	53.50	P	8830	10280	1100	17730	1897	12320	1318	1711
	53.50	V	9580	12230	1309	21810	2334	12320	1318	2332
	58.40[1]	V	12600	12230	1428	21700	2534	11280	1318	2532
	61.10[1]	V	14240	12270	1499	21710	2653	10790	1318	2651
10¾	51.00	P	3750	8730	890	17220	1756	14240	1452	1602
	55.50	P	5040	8840	981	17320	1923	13080	1452	1754
	60.70	P	6790	8900	1081	17360	2107	11960	1452	1922
	65.70	P	8540	8980	1180	17420	2289	11050	1452	2088
	71.10[1]	P	9720	9060	1288	17490	2487	10210	1452	2269
	76.00[1]	P	10790	9110	1385	17530	2665	9550	1452	2431
	65.70	V	8920	10690	1405	21430	2816	11050	1452	2847
	71.10[1]	V	11760	10790	1534	20770	2953	10210	1452	3094
	76.00[1]	V	14300	10850	1649	19430	2953	9550	1452	3315

[1] See notes.

TABLE 2—Minimum Collapse Resistance Under Axial Tension Stress[1]

Tentative Grade V-150 Casing

Outside Diameter D	Wall Thickness t	Weight Per Foot T & C	D/t	Plain End Area	UNIT TENSILE STRESS—psi Thousands																Area of Pipe Wall under Last Perfect Tread (API)
					0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	
Ins.	Ins.	Lbs.		Sq. Ins.	ADJUSTED COLLAPSING PRESSURE—psi																Sq. Ins.
5	.296	15.00	16.891	4.374	*11010	*11010	*11010	*11010	*11010	*11010	*11010	10930	10670	10400	10120	9840	9540	9240	8920	8580	3.271
5	.362	18.00	13.812	5.275	16420	16160	15890	15600	15310	15000	14690	14350	14010	13660	13300	12920	12530	12130	11720	11270	4.171
5½	.361	20.00	15.235	5.828	14460	14230	13990	13740	13480	13210	12930	12640	12340	12030	11710	11380	11040	10690	10320	9930	4.613
5½	.415	23.00	13.253	6.630	17060	16790	16510	16210	15910	15590	15260	14910	14560	14190	13820	13430	13020	12610	12170	11710	5.414
7	.408	29.00	17.157	8.449	*10480	*10480	*10480	*10480	*10480	*10480	*10480	*10480	10420	10160	9890	9610	9320	9020	8710	8380	6.899
7	.453	32.00	15.453	9.317	14180	13950	13720	13470	13220	12960	12680	12400	12100	11800	11490	11160	10820	10480	10120	9730	7.766
7	.498	35.00	14.056	10.173	16150	15890	15630	15340	15060	14760	14450	14120	13780	13440	13080	12710	12330	11930	11520	11090	8.622
7	.540	38.00	12.962	10.959	17410	17130	16840	16540	16230	15910	15570	15220	14860	14490	14100	13700	13290	12870	12420	11950	9.408
7⅝	.430	33.70	17.732	9.720	*9460	*9460	*9460	*9460	*9460	*9460	*9460	*9460	*9460	*9460	9420	9150	8880	8590	8300	7980	8.029
7⅝	.500	39.00	15.250	11.192	14440	14210	13970	13720	13470	13200	12920	12620	12320	12010	11700	11360	11020	10670	10300	9910	9.501
7⅝	.595	45.30[2]	12.815	13.141	17590	17310	17020	16710	16400	16070	15730	15380	15010	14630	14250	13840	13430	13000	12550	12080	11.450
9⅝	.545	53.50	17.660	15.547	*9580	*9580	*9580	*9580	*9580	*9580	*9580	*9580	*9580	*9580	9480	9210	8930	8650	8350	8030	13.408
9⅝	.595	58.40[2]	16.176	16.879	*12600	*12600	*12600	*12600	12390	12140	11890	11620	11340	11060	10760	10460	10140	9820	9480	9120	14.741
9⅝	.625	61.10[2]	15.400	17.672	14240	14010	13780	13530	13280	13010	12740	12450	12150	11850	11530	11210	10870	10520	10160	9780	15.533
10¾	.595	65.70	18.067	18.982	*8920	*8920	*8920	*8920	*8920	*8920	*8920	*8920	*8920	*8920	*8920	8900	8630	8360	8070	7760	16.592
10¾	.650	71.10[2]	16.538	20.625	*11760	*11760	*11760	*11760	*11760	*11760	11520	11260	10990	10720	10430	10140	9830	9520	9190	8840	18.234
10¾	.700	76.00[2]	15.357	22.101	14300	14070	13840	13580	13330	13070	12790	12500	12210	11900	11580	11250	10920	10570	10200	9820	19.711

[1] Tentative.
[2] Sizes indicated are non-API.
* Elastic collapse.
Example: For 32-lb. 7-inch D casing under a tensile load of 14250 psi, interpolate as follows: 13720 — 13470 = 250 psi × (15000 — 14250) ÷ 5000 = 38 psi + 13470 = 13508 psi.

TABLE 1—API Grade P-110 and Tentative Grade V-150—(Continued)

(Furnished with Long Threads and Couplings)

DIMENSIONS AND INTERNAL PRESSURES

Size: Outside Diameter	Weight Per Foot: Nominal: Threads and Coupling	Weight Per Foot: Plain end	DIMENSIONS: Wall Thickness	DIMENSIONS: Inside Diameter	DIMENSIONS: Drift Diameter	DIMENSIONS: COUPLING: OUTSIDE DIA: API or Buttress	DIMENSIONS: COUPLING: OUTSIDE DIA: [1] [3] Spec. Clearance API or Buttress	DIMENSIONS: COUPLING: LENGTH: API	DIMENSIONS: COUPLING: LENGTH: [1] Buttress	Steel Grade	INTERNAL PRESSURES: TEST: [3] [4] Mill	INTERNAL PRESSURES: TEST: At Fiber Stress Equal to 80 % of min. Yield Strg.	INTERNAL PRESSURES: [6] Yield (min)	INTERNAL PRESSURES: ULTIMATE[1]: Min.	INTERNAL PRESSURES: ULTIMATE[1]: Avg.
Ins.	Lbs.		Ins.								psi				
5	15.00	14.87	.296	4.408	4.283	5.563	5.375	7¾	9⅛	P	10400	10400	11390	13620	15040
	18.00	17.93	.362	4.276	4.151	5.563	5.375	7¾	9⅛	P	10000	12700	13940	16650	18390
	15.00	14.87	.296	4.408	4.283	5.563	5.375	7¾	9⅛	V	12000	14200	15540	17050	18940
	18.00	17.93	.362	4.276	4.151	5.563	5.375	7¾	9⅛	V	12000	17400	19000	20850	23170
5½	17.00	16.87	.304	4.892	4.767	6.050	5.875	8	9¼	P	9700	9700	10640	12710	14040
	20.00	19.81	.361	4.778	4.653	6.050	5.875	8	9¼	P	10000	11600	12640	15100	16670
	23.00	22.54	.415	4.670	4.545	6.050	5.875	8	9¼	P	10000	13300	14520	17360	19170
	20.00	19.81	.361	4.778	4.653	6.050	5.875	8	9¼	V	12000	15800	17230	18900	21000
	23.00	22.54	.415	4.670	4.545	6.050	5.875	8	9¼	V	12000	18100	19810	21730	24150
7	26.00	25.66	.362	6.276	6.151	7.656	7.375	9	10	P	9100	9100	9960	11890	13140
	29.00	28.72	.408	6.184	6.059	7.656	7.375	9	10	P	10000	10300	11220	13410	14800
	32.00	31.68	.453	6.094	5.969	7.656	7.375	9	10	P	10000	11400	12460	14880	16440
	35.00	34.58	.498	6.004	5.879	7.656	7.375	9	10	P	10000	12500	13690	16360	18070
	38.00	37.26	.540	5.920	5.795	7.656	7.375	9	10	P	10000	13600	14850	17740	19590
	29.00	28.72	.408	6.184	6.059	7.656	7.375	9	10	V	12000	14000	15300	16790	18650
	32.00	31.68	.453	6.094	5.969	7.656	7.375	9	10	V	12000	15500	16980	18640	20710
	35.00	34.58	.498	6.004	5.879	7.656	7.375	9	10	V	12000	17100	18670	20490	22770
	38.00	37.26	.540	5.920	5.795	7.656	7.375	9	10	V	12000	18500	20250	22220	24690
7⅝	29.70	29.04	.375	6.875	6.750	8.500	8.125	9¼	10⅜	P	8700	8700	9470	11310	12490
	33.70	33.04	.430	6.765	6.640	8.500	8.125	9¼	10⅜	P	9900	9900	10860	12970	14320
	39.00	38.05	.500	6.625	6.500	8.500	8.125	9¼	10⅜	P	10000	11500	12630	15080	16660
	33.70	33.04	.430	6.765	6.640	8.500	8.125	9¼	10⅜	V	12000	13500	14800	16240	18050
	39.00	38.05	.500	6.625	6.500	8.500	8.125	9¼	10⅜	V	12000	15700	17210	18890	20980
	45.30[1]	44.67	.595	6.435	6.310	8.500	8.125	9¼	10⅜	V	12000	18700	20480	22470	24970
9⅝	43.50	42.70	.435	8.755	8.599	10.625	10.125	10½	10⅝	P	8000	8000	8700	10400	11480
	47.00	46.14	.472	8.681	8.525	10.625	10.125	10½	10⅝	P	8600	8600	9440	11280	12460
	53.50	52.85	.545	8.535	8.379	10.625	10.125	10½	10⅝	P	10000	10000	10900	13020	14380
	53.50	52.85	.545	8.535	8.379	10.625	10.125	10½	10⅝	V	12000	13600	14870	16310	18120
	58.40[1]	57.38	.595	8.435	8.279	10.625	10.125	10½	10⅝	V	12000	14800	16230	17800	19780
	61.10[1]	60.08	.625	8.375	8.219	10.625	10.125	10½	10⅝	V	12000	15600	17040	18700	20780
10¾[2]	51.00	49.50	.450	9.850	9.694	11.750	11.250	8	10⅝	P	7400	7400	8060	9630	10630
	55.50	54.21	.495	9.760	9.604	11.750	11.250	8	10⅝	P	8100	8100	8860	10590	11700
	60.70	59.40	.545	9.660	9.504	11.750	11.250	8	10⅝	P	8900	8900	9760	11660	12880
	65.70	64.53	.595	9.560	9.404	11.750	11.250	8	10⅝	P	9700	9700	10660	12730	14060
	71.10[1]	70.12	.650	9.450	9.294	11.750	11.250	8	10⅝	P	10000	10600	11640	13910	15360
	76.00[1]	75.13	.700	9.350	9.194	11.750	11.250	8	10⅝	P	10000	11500	12540	14980	16540
	65.70	64.53	.595	9.560	9.404	11.750	11.250	8	10⅝	V	12000	13300	14520	15940	17710
	71.10[1]	70.12	.650	9.450	9.294	11.750	11.250	8	10⅝	V	12000	14500	15870	17410	19350
	76.00[1]	75.13	.700	9.350	9.194	11.750	11.250	8	10⅝	V	12000	15600	17090	18750	20840

[1] See notes.

TABLE 3—14,000 and 18,600-Foot Casing Combination Designs

SIZE O. D. 7 INCH — Mud Density 119.69 Pounds Per Cubic Foot or 16 Pounds Per Gallon

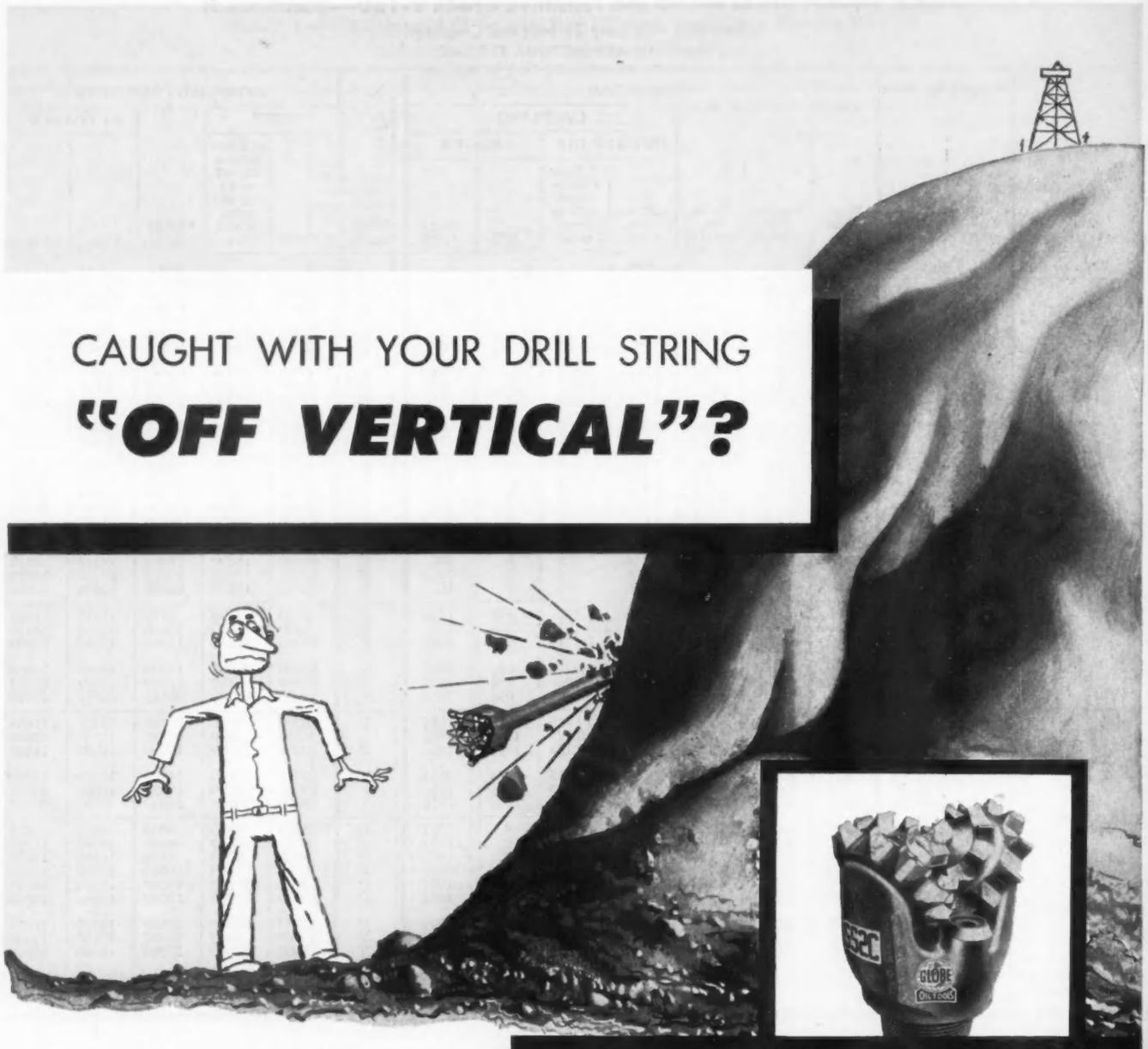
Combination	Depth	Steel Grade or Minimum Yield	Nominal Weight	Wall Thickness	JOINT: TYPE: Thread	JOINT: TYPE: Upset	JOINT: DIAMETER: Inside of Jt.	JOINT: DIAMETER: Drift	JOINT: DIAMETER: Outside of Jt.	PIPE: Amount	PIPE: Weight	[1] Tension Load Top of Section	SAFETY FACTOR (MIN): [1] Collapse Bottom of Section	SAFETY FACTOR (MIN): TOP OF SECTION: Tension	SAFETY FACTOR (MIN): TOP OF SECTION: Pipe Yield Strength	SAFETY FACTOR (MIN): TOP OF SECTION: Internal Pressure (Yield)
	Ft.		Lb./Ft.	In.			In.	In.	In.	Ft.	Lb.	Lb.				
	2650	P-110	32	.453	Buttress	None	6.094	5.969	7.656	2650	84800	461350	3.859	2.53	2.22	1.070
	10800	P-110	32	.453	Long API	None	6.094	5.969	7.656	8150	260800	376550	1.128	2.00	2.26	1.070
A	12750	P-110	35	.498	Long API	None	6.004	5.879	7.656	1950	68250	115750	1.126	7.17	8.19	1.176
	14000	P-110	38	.540	Long API	None	5.920	5.795	7.656	1250	47500	47500	1.128	18.94	21.78	1.276
	2200	P-110	32	.453	Buttress	None	6.094	5.969	7.656	2200	70400	448000	4.643	2.60	2.28	1.070
	10900	P-110	32	.453	Long API	None	6.094	5.969	7.656	8700	278400	377600	1.128	2.00	2.26	1.070
B	14000	V-150	32	.453	Long API	None	6.094	5.969	7.656	3100	99200	99200	1.218	9.07	11.74	1.459
	2200	V-150	32	.453	Long API	None	6.094	5.969	7.656	2200	70400	448000	6.605	2.00	2.60	1.459
	10900	P-110	32	.453	Long API	None	6.094	5.969	7.656	8700	278400	377600	1.128	2.00	2.26	1.070
C	14000	V-150	32	.453	Long API	None	6.094	5.969	7.656	3100	99200	99200	1.218	9.07	11.74	1.459
					18,600 Feet Casing Combination Design											
	5100	V-150	32	.453	Buttress	None	6.094	5.969	7.656	5100	163200	613200	2.735	2.21	2.27	1.098
	14300	V-150	32	.453	Long API	None	6.094	5.969	7.656	9200	294400	450000	1.126	2.00	2.58	1.098
	16900	V-150	35	.498	Long API	None	6.004	5.879	7.656	2600	91000	155600	1.126	6.35	8.31	1.207
D	18600	V-150	38	.540	Long API	None	5.920	5.795	7.656	1700	64600	64600	1.126	16.56	21.84	1.309

[1] Based on Minimum Collapsing Pressure, and effect of axial tension included.

Continued on Page 164

CAUGHT WITH YOUR DRILL STRING

"OFF VERTICAL"?



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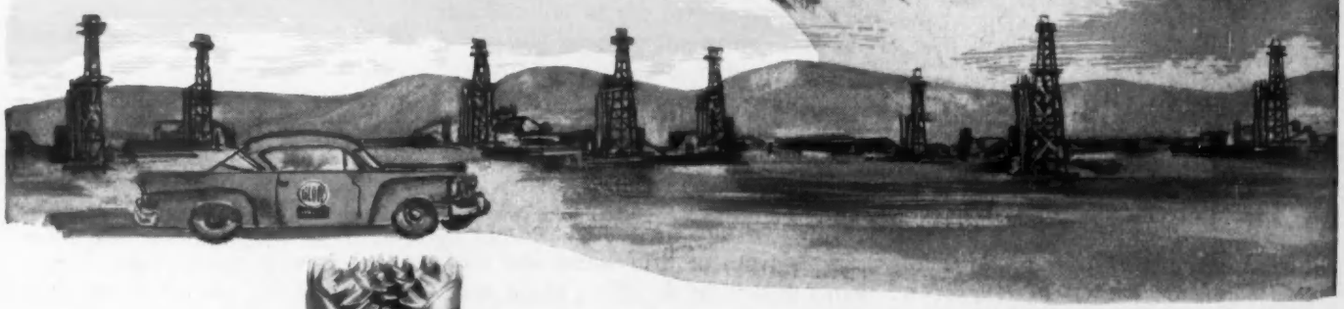

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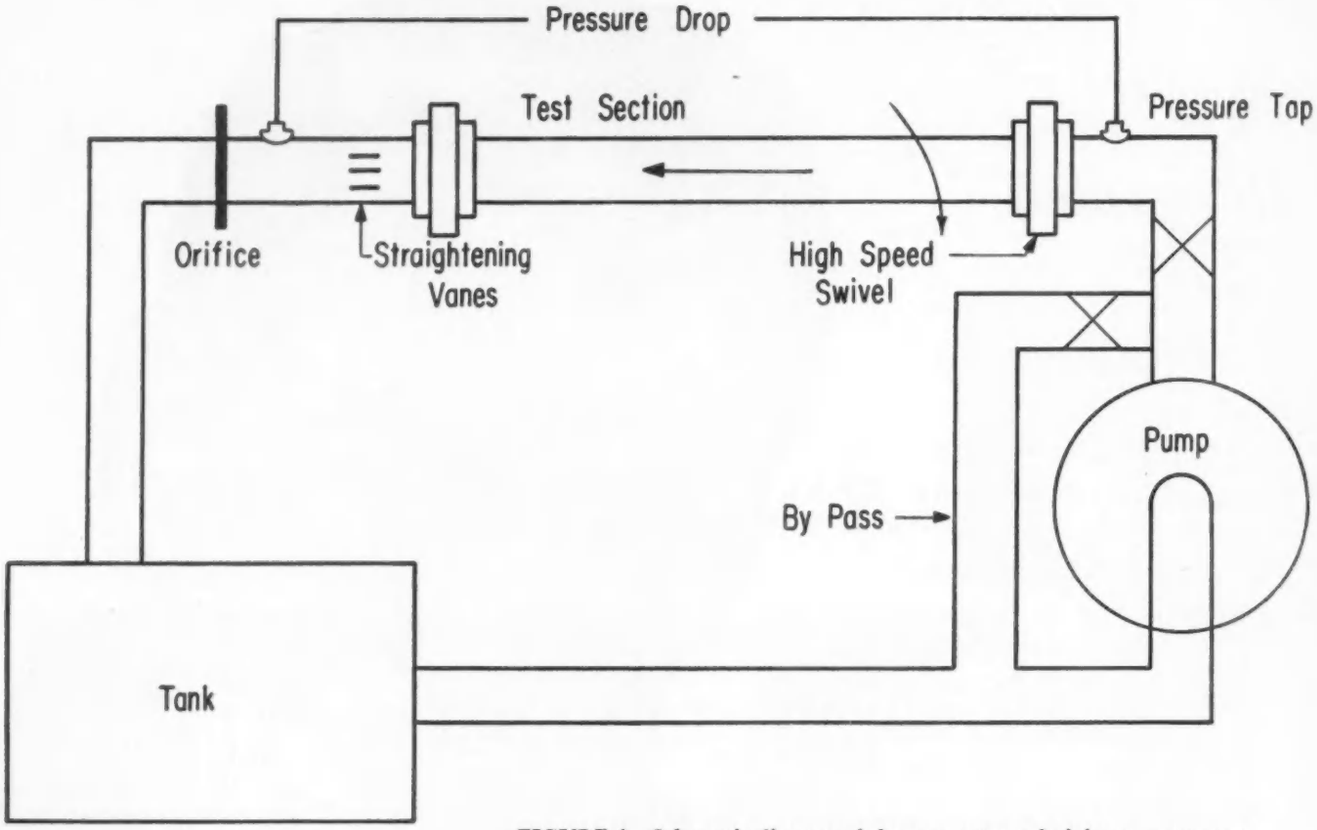


FIGURE 1—Schematic diagram of the apparatus and piping arrangement.

Drill pipe rotation reduces pressure drop

A net power saving results from operating drill pipe above 100 rpm.

By Howard Ferrell, Graduate Assistant,
E. C. Fitch, Assistant Professor, and
J. H. Boggs, Associate Professor,
Oklahoma A. and M. College, Stillwater, Okla.

RECENT DEVELOPMENTS in drilling have enabled greater penetration depths than were formerly thought possible. With greater depths have come increased circulation problems. One of these problems is the power requirement of the circulation system. This means that an accurate prediction must be made of this requirement. Much work on the detailed consideration of hydraulic losses has been done to analyze the effect of various types of drill stems and tool joints as well as the effect of bit nozzles. Some work also has been done on losses due to the circulation fluid itself. However, a detail often overlooked in the consideration of hydraulic losses is the effect of pipe rotation.

F. Levy[1] noticed the effect of rotation on pressure drop while studying heat transfer of gases in rotating diffusers. He obtained a reduction of the pressure loss through the rotating section, and attempted to explain the phenomena by defining a new coefficient of resistance to flow. Levy asserted that for otherwise similar condition, the coefficient of resistance to flow through rotating tubes always would be lesss than the coefficient for flow through stationary tubes. Besides Levy's recognition of the phenomena, little work has been done to explain the effect of rotation on the flow characteristics.

Analysis of the Problem. The motion of a particle of fluid in a straight tube is governed by forces due to frictional and dynamic resist-

Presented at American Society of Mechanical Engineers, Petroleum Mechanical Engineering Conference, Tulsa, Sept. 22-25, 1957, under the title An Investigation of Pressure Drop Through a Rotating Pipe.

ances. If the tube is rotated, the particle also is affected by centrifugal forces.

To determine the relation of pressure drop to the other variables affecting the flow, a dimensional study was made.

RESULTS OF DIMENSIONAL STUDY

	Variables	Dimension
r	Radius of pipe	L
Q	Flow rate of fluid	L^3T^{-1}
μ	Viscosity of fluid	$ML^{-1}T^{-1}$
l	Length of pipe	L
Δp	Pressure loss of fluid over length l	$ML^{-1}T^{-2}$
ρ	Density of fluid	ML^{-3}
ω	Angular velocity of pipe	T^{-1}

From Buckingham's theorem using (r, Q, μ) as a probasic triad, the following four dimensionless groups were obtained:

$$\frac{l}{r}, \frac{r^3\Delta p}{Q\mu}, \frac{Q\rho}{r\mu}, \frac{r^3\omega}{Q}.$$

Operating on these groups by dimensionless constants to place them in a more useful form for studying their physical significance, gave the four dimensionless groups:

$$\frac{l}{r}, \frac{\pi r^4\Delta p}{8Ql}, \frac{2Q\rho}{\pi r\mu}, \frac{r^2\omega\rho}{\mu}$$

From the dimensional study it was noted that the pressure loss could be expressed as:

$$\Delta p = \left(\frac{8Ql\mu}{\pi r^4}\right)\phi\left[N_{Re}\frac{l}{r}, \frac{r^2\omega\rho}{\mu}\right] \quad (1)$$

where N_{Re} is Reynolds' Number.

Apparatus. The essential part of the experimental apparatus was the test section. A 19-foot, 5-inch length of BW gage 11 seamless low carbon 2-inch tubing was used for this section. The tubing was secured by four self-aligning bearings to a channel frame which was bolted to the floor.

To rotate the test section, a sheave was fastened to the tube with a tapered bushing and a variable drive was used to rotate the tubing.

Special high speed swivel joints were used to connect the stationary approach and discharge sections to the test section. The swivels were made with the same internal diameter as the tubing, and were silver-soldered to the tube to facilitate good alignment.

An orifice meter assembly was fabricated into the discharge section. The pressure taps, the tapped flange, orifice plates, and straightening vanes were manufactured and assembled in accordance with accepted specifications. There was no specification for the location of the orifice plate after a rotating pipe, so the orifice was located as prescribed for the situation in which two ells in perpendicular planes precede the meter-run. The approach to the test section was a 25-inch length of straight tubing. Figure 1 shows a schematic diagram of the apparatus and piping arrangement.

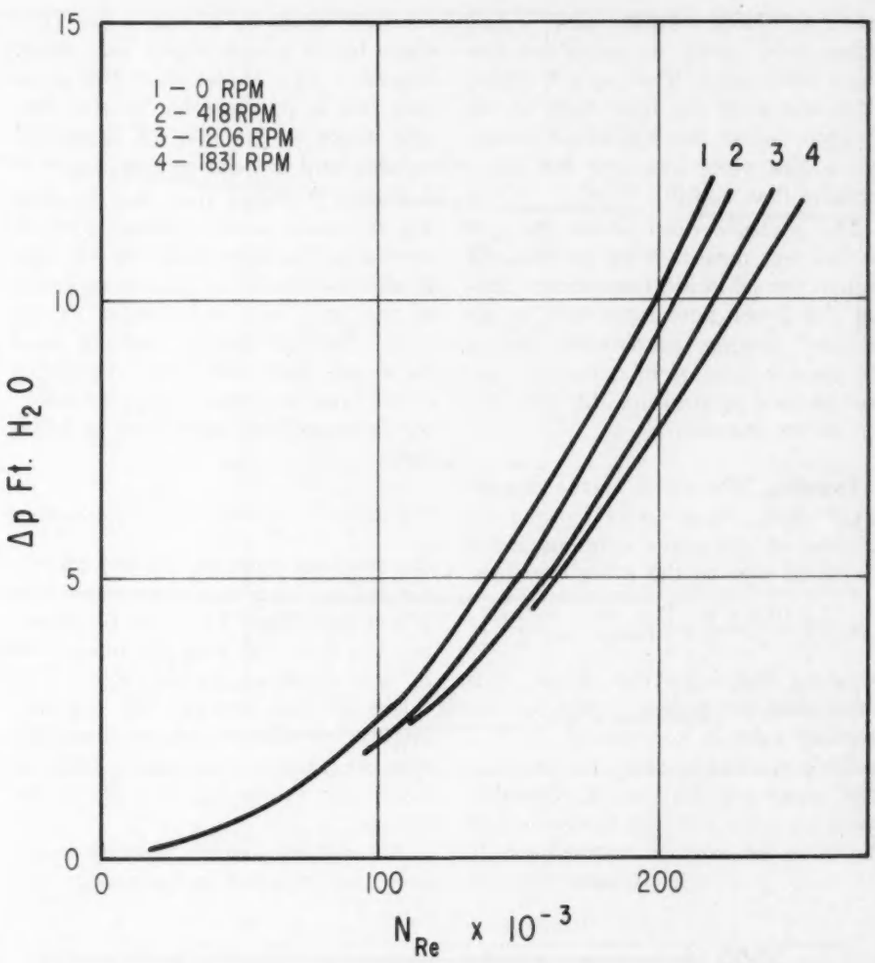


FIGURE 2—Pressure drop versus Reynolds number for constant angular velocities.

Procedure. Information necessary to study the pressure loss characteristics of flow in a rotating pipe was obtained by making differential static pressure measurements across the test section, which was rotated at various angular velocities and for various flow rates.

The data was recorded in a series of test runs which consisted of setting the selected flow rate and varying the angular velocity of the test section. With the flow settings remaining unchanged, the angular velocity was varied with the variable drive in increments of 200 rpm from 400 rpm to 2,400 rpm. Readings also were made at angular velocities of zero and 275 rpm.

With each angular velocity, adequate time was given to allow the flow to stabilize before any recording was made. At each stop, three readings of each the orifice manometer and the pressure drop manometer were made over a two-minute interval. The average of the readings was used in calculations. The rpm was recorded by a tachometer over the same two-minute intervals.

The barometer was read at the beginning and end of each test run. Air and water temperatures also were noted at the beginning and end as well as at irregular intervals during the run. Air temperature was measured in the vicinity of the manometers, and the water temperature was measured in the circulation tank.

Test runs were made for flow rates of 15, 25, 35, 50, 70, 90, and 120 gpm. Three orifice plates with diam-

eters of 0.603, 1.005, and 1.417 inches were used to measure the seven flow rates. The small orifice plate was used for flow rates up to 35 gpm, while the 1.005-inch diameter orifice plate was used for intermediate flow rates.

The pressure drop across the test section was measured by an inclined carbon tetrachloride manometer during the lower flow rates and by an inclined mercury manometer during the greater rates. A mercury manometer as used to measure the differential across the orifice.

Results. The result of the dimensional study, Equation (1), shows the relation of pressure drop over the length of pipe to the other variables.

$$\Delta p = \left(\frac{8Q1\mu}{r^4}\right) \phi \left[N_{Re}, \frac{1}{r}, \frac{r^2\omega\rho}{\mu}\right]$$

Breaking the equation down, it is noted that the pressure drop for the rotating tube is expressed as Poiseuille's pressure drop for laminar flow times a function of Reynolds' number, ratio of length to radius, and the ratio of angular momentum to viscosity. Since 1, r, and μ are constant for a given tube and fluid, Equation (1) shows that the pressure loss is proportional to the flow rate times a function of Reynolds' number and angular momentum.

Figure 2 shows that the pressure loss decreases as the rotational speed increases. The curve taken at 400 rpm is almost parallel to the curve taken at zero rpm but is displaced to the right. As the angular velocity was increased above 400 rpm, the slopes of the lines of constant angular velocity decreased to a minimum at 1,800 rpm.

Figure 3 is a plot of $\frac{\Delta p \pi r^4}{8Q1\mu}$ vs N_{Re} for constant rpm on log-log coordinates. On this plot, the zero rpm line is a straight line. The lines representing less than 400 rpm are parallel to it, but displaced to the right. The slopes of lines representing constant angular velocities greater than 400 rpm decrease to a minimum value at 1,800 rpm as the angular velocity increases.

All constant angular velocity curves make a sharp break close to values of Reynolds' number equal to 100,000 and approach the stationary pipe flow condition asymptotically.

Figure 4 shows that the pressure loss reduction reaches a minimum between 1,200 rpm and 2,000 rpm, depending on the flow rate. Above the angular velocity at which the minimum values occurred, the slope of the pressure drop curves increased slowly as the rpm increased.

Equation (1), and Figures 2, 3, and 4 imply that when a proper balance of dynamic and centrifugal forces exist a reduction of pressure loss is achieved. The term $\frac{r^2\omega\rho}{\mu}$ from Equation (1) is a function of the amount of work the fluid may absorb. The rotational work absorbed by the fluid tends to stabilize or restrict the random motion of the water particles. For flow rates corresponding to Reynolds' number greater than 100,000, the dynamic forces overcome the rotational effect and the pressure drop approaches the value for the stationary pipe condition. For flow rates corresponding to Reynolds' number less than 30,000, centrifugal forces are greater than are needed to stabilize the flow and the flow rate is retarded.

From this study, it would appear that the pressure drop varies from values produced by streamline flow as the lower limit to values produced by pure turbulent flow as the upper limit. When streamline flow exists the value of

$\phi\left[\ , N_{Re}, \frac{1}{r}, \frac{r^2\omega\rho}{\mu}\right]$ is equal to unity,

and the constant angular velocity lines would plot as straight horizontal lines on a log-log coordinate plot.

Close observation on Figure 4 reveals that—for all flow rates—at least half of the pressure drop reduction occurred by 600 rpm. Even for the maximum flow rate corresponding to a Reynolds' number of 218,000, more than 80 percent of the total reduction occurred by 1,200 rpm. These observations become important when considering this work in light of actual oil well drilling where the rotary speed is limited, depending on various conditions.

Since use of the orifice in a flow with swirl was not in accord with best practice, it was necessary to determine

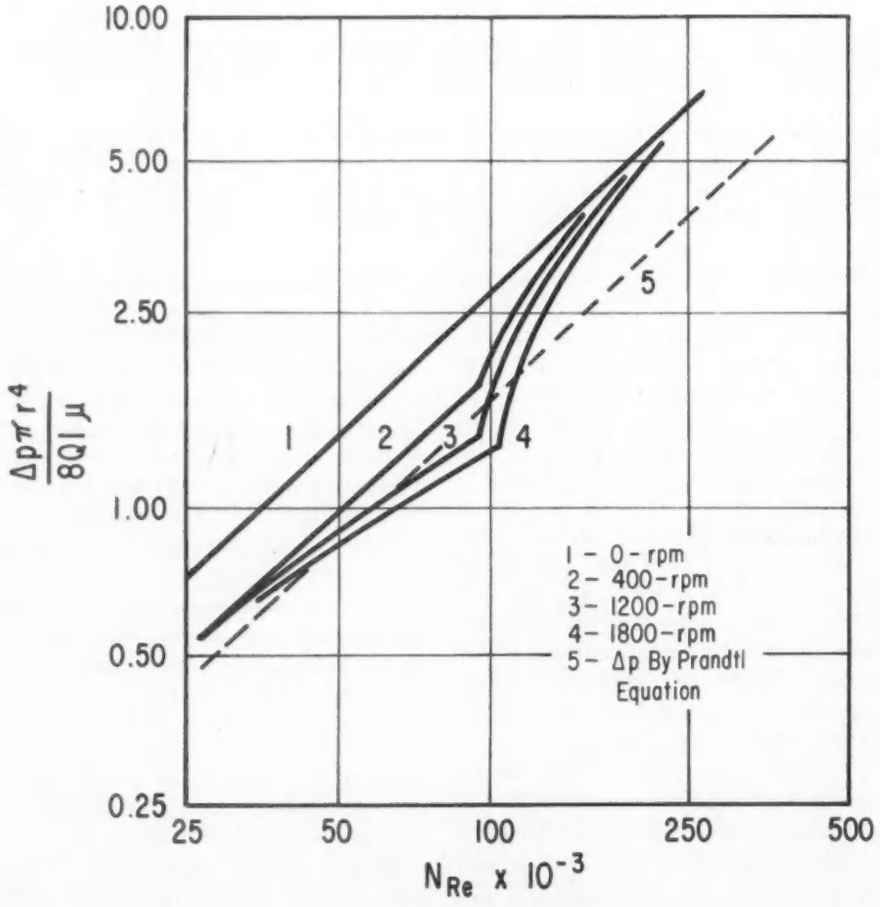


FIGURE 3—$\Delta p \pi r^4/8Q1\mu$ versus Reynolds number for constant angular velocities.

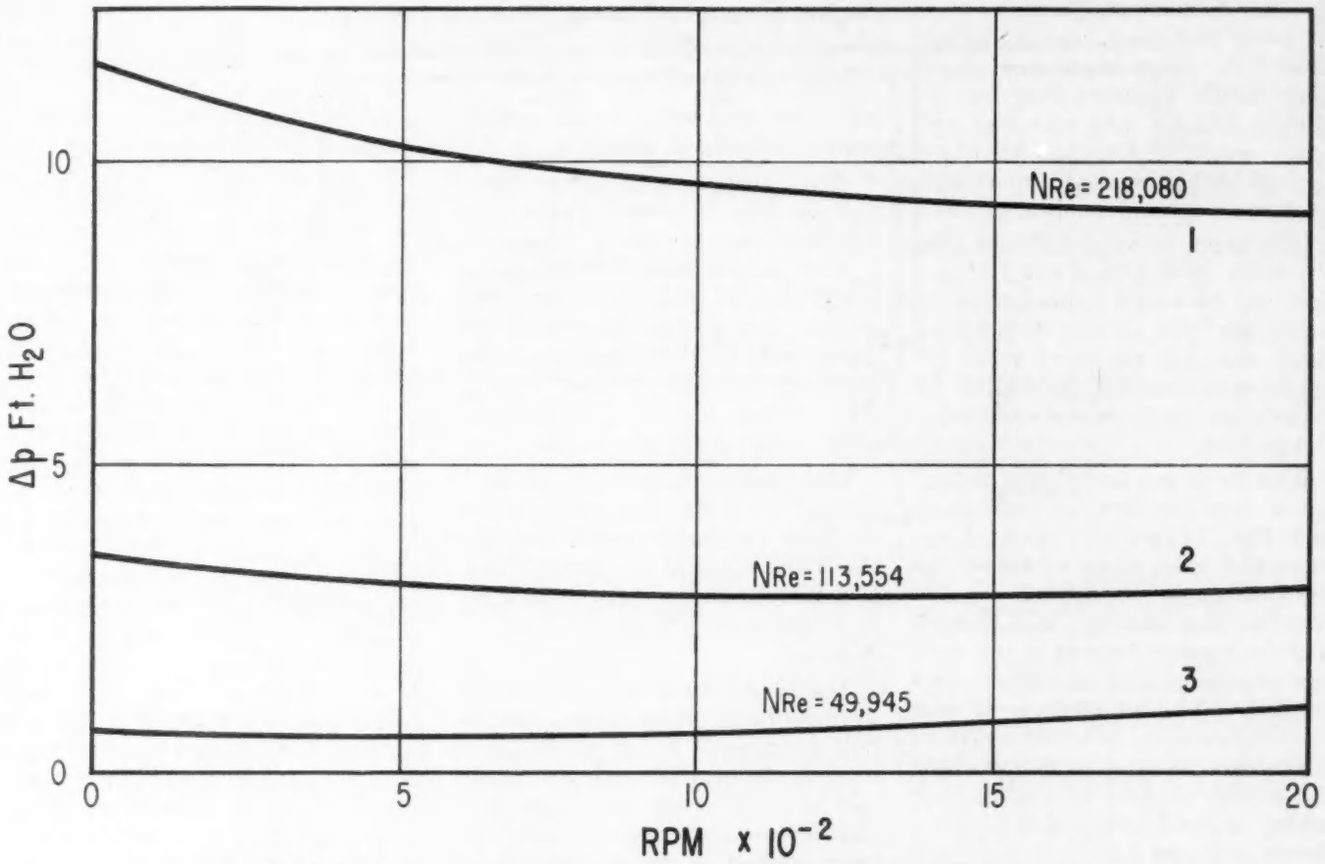


FIGURE 4—Pressure drop versus angular velocities for constant Reynolds number.

if the rotation affected the accuracy of the flow measurement. Results of a volumetric check indicated that rotation did not affect any flow measurements.

To compare the data, all flow calculations were made for average environmental conditions during the experiment. Thus, flow rates are for atmospheric pressure of 29.35 inches of mercury, a temperature of 90° F. and the flowing temperature of 86° F. An average value of angular velocity was used to plot the lines of constant angular velocity of Figures 2 and 3. Also, an average value of Reynolds' number was used to tabulate the constant N_{Re} values of Figure 4.

It is believed that the source of the greatest error possibly is the presence of air within the system. Air would be separated by the pipe rotation. If the air became separated, two-phase flow would exist and the resulting reading of presure drop would be much too high.

It is recommended that future tests be conducted in a closed system. Since facilities were not available for a closed system, every effort was made to eliminate the air. Air bleeds were installed at each pipe tap, as well as

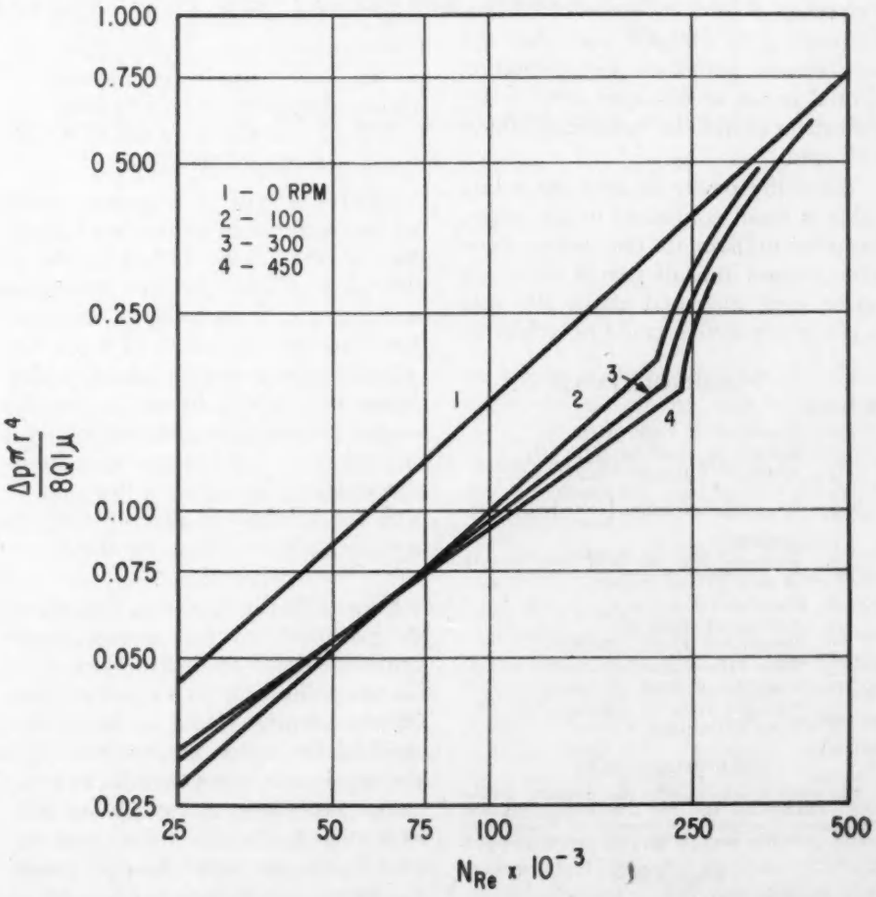


FIGURE 5—$\Delta p \pi r^4 / 8Ql\mu$ versus Reynolds number for constant angular velocities for drill pipe.

on each manometer. Care was taken to assure that there was no leakage around the pump impeller or at any place in the piping; also, the discharges into the tank were kept well under water. Water was circulated through the system several times prior to the test to allow removal of air.

The largest standard deviation from the mean for any data was 1.25 percent and the largest residual from the mean was 1.30 percent. Considering these errors and the errors due to averaging and rounding, the data of this experiment can be reproduced within ± 4 percent.

This work was an original investigation into the effect of rotation on fluid flow. More experimental and theoretical work is needed before this study can be directly applied to petroleum drilling. However, it is believed that the results presented in this work can be extrapolated by dimensionless methods to lend an insight as to what might be expected in a field situation. The values obtained by extrapolating the observed data of the 2¼-inch tubing to the 5½-inch drill pipe are shown in Figure 5 .

Figure 5 reveals that for 5½-inch drill pipe the stabilizing effect should extend to a value of Reynolds' Number equal to 200,000 and that the maximum pressure loss reduction should occur at 450 rpm with a significant reduction occurring above 100 rpm.

Since the power to turn the rotary table is small compared to the power required to maintain circulation, these observations indicate that if the rotary speed were increased above 100 rpm a net power saving could be achieved.

NOMENCLATURE

Symbols

d	Diameter of pipe (ft.)
l	Length of rotating pipe (ft.)
μ	Absolute viscosity lbs./ft. sec.
N_{Re},	Reynolds' Number $\left(\frac{\rho v d}{\mu}\right)$ (Dimensionless)
Δp	Pressure loss of fluid over length of pipe (ft. of H_2O)
ϕ	Function of
r	Radius of pipe (ft.)
ρ	Density of Fluid (lbs./ft.^{3})
Q	Flow rate of fluid (ft.^{3}/sec.)
v	Velocity of fluid (ft./sec.)
ω	Angular velocity (radians/sec.)
T	Time (minutes)

ACKNOWLEDGMENT

The authors acknowledge the graduate fellowship awarded by the Pan American Petroleum Foundation (formerly the Standolind Foundation) which provided financial support for this project.

REFERENCE

[1] F. Levy, Flow Phenomena in Revolving Tubes, Forschungsarbeiten auf dem Gebietc des Ingenieurwesens, No. 322, pp. 8-45, 1929.

Higher Strength Casing

Continued from Page 155

ing. This string is 13,350 pounds lighter than the A string.

The C string is a further modification in that 32-pound V-150 with the API Long T and C connection is used on top instead of 32-pound P-110 buttress. This illustrates the increased joint strength imparted by the higher yield in V-150 and avoids the cross-over problem. Further, it provides a high internal yield pressure safety factor in the top section.

Using barge transportation, it is estimated that the delivered cost in southern Louisiana would find that the B string would run about 3 percent more than the A string and the C string about 6.9 percent over the A string.

The conditions of mud weight and depth in these strings suggest bottom-hole pressures of 11,500 psi. V-150 is made in the heavier weights of 7-inch, and a string could be designed to 18,600 feeet in 16 ppg mud using the same method of design. String D is such a string. These deeper conditions suggest bottom-hole pressures of almost 15,500 psi. At a safety factor of 1⅛-inch collapse 7-inch O.D. 38-pound P-110 would be capable of withstanding bottom-hole pressures of 11,670 psi and the same size of V-150 would withstand 15,475 psi.

Tables 1 and 2 suggest some heavier weights in protection strings. Because the elastic failure mode of collapse in lighter weights limits the amount of gain in collapse resistance that can be realized through increased yield strengths alone, it becomes necessary to go to heavier weights of casing in conjunction with the higher strength steels. This limits and restricts the bit sizes that can be used for subsequent drilling through any given size of casing, when bottom-hole pressures increase.

Eventually, such a situation limits the possibility of just setting longer strings in order to drill deeper wells. Going to slim hole techniques at these extreme depths would be costly because of the hydraulics involved. The alternative would seem to be to go to larger protection strings. Long 9⅝-inch strings are now being used below 14,000 feet and the 53.5-pound weight permits the passage of only an 8⅜-inch bit. This allows but minimum clearance through which to set 7-inch as an oil string.

As often happens, formations are such that the 7-inch must be set before the desired depth is reached and the final string is limited to 5 inches which is difficult to set, particularly in holes drilling below the heavier weights of 7 inches. Ten and three-quarter-inch casing never has been too popular for long settings because it is made in walls too light to give setting depths near those of 9⅝-inch.

Further, API 8 round threaded connections are not as efficient in the larger sizes and the highly efficient buttress threads develop adequate tension values for long settings. However, 10¾-inch 0.595-inch wall in P-110 would have collapsed resistance nearly 97 percent of 9⅝-inch 53.5-pound P-110 and would accept a 9½-inch bit, over 1-inch larger than the 8⅜-inch bit possible through the heavy 9⅝-inch. Seven and five-eighths inch would have a better chance to be set in such a hole than the 7-inch had in the 9⅝-inch.

Assuming that the well conditions were such and the 7⅝-inch had to be set before the objective was reached and the 39-pound 7⅝-inch would be adequate, the allowable bit size through the 7⅝-inch would be 6½-inch rather than the 5¾-inch hole through 7-inch 38-pound or the 5⅞-inch hole through the 7-inch 32-pound in the strings shown earlier.

If the hole conditions were improved, 5½-inch casing in the 6½-inch hole would be conceivable. Such an enlarged casing program also would allow the use of large diameter strings of drill pipe to great depths which would provide a good hydraulic situation, particularly on internal upset drill pipe construction.

NOTES

[1] Sizes or values indicated are non-API.
[2] 10¾-inch O.D. size API joint is furnished with short couplings only.
[3] High test pressures for casing furnished with special clearance couplings are approximately 85 percent of the listed pressures.
[4] Present mill equipment limits test pressure to 12,000 psi on T and C casing, but API test pressure limit is 10,000 psi maximum. Present mill equipment limits test pressure to 10,000 psi maximum on plain end casing.
[5] Tension strengths for casing furnished with special clearance couplings are approximately 90 percent of the listed strengths.
[6] Based on 87.5 percent for internal pressure at minimum yield strength.
[7] V-150 values obtained from National Tube Division, U. S. Steel Corporation bulletin on V-150 Casing, 1957.

REFERENCE

[1] A. C. Temmel, Combination Casing Strings, World Oil, June, 1949, Vol. 129, No. 2, Pages 111, 112, 114 and 116.

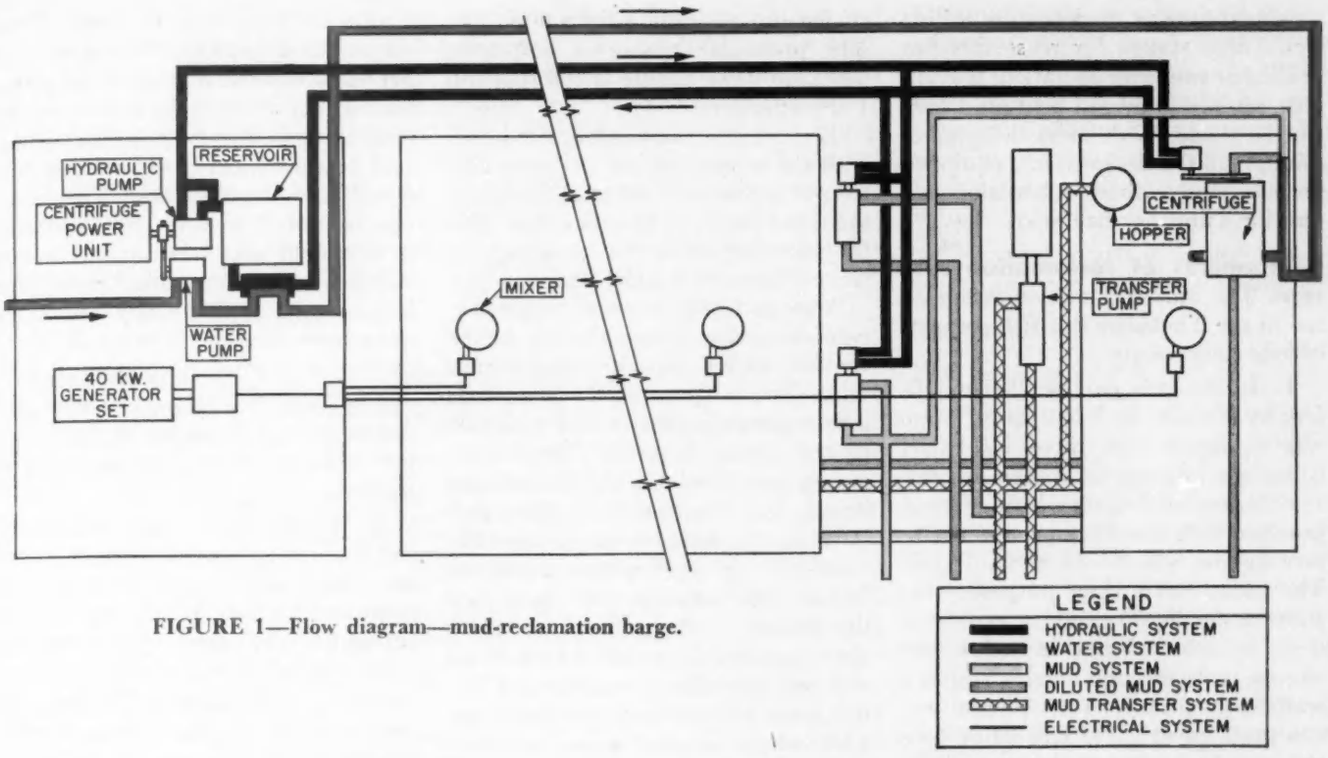


FIGURE 1—Flow diagram—mud-reclamation barge.

Mud reclamation is found successful

A total net saving of more than $800,000 afforded one company in less than 18 months of operation.

By D. M. Jeffus, Jr., and V. T. Jones, Jr.
Gulf Oil Corporation, Cutoff, La.

SAVINGS IN over-all mud costs can be effected by the use of a mud reclamation system. Three prerequisites are required for economical operation:

1. A shallow field with a concentration of drilling and workover operations.

2. Only one type of mud should be used to keep the amount of equipment to a minimum.

3. The necessary equipment to centrifuge and store the surplus mud built up in normal operations must be available.

The reclamation system has been a worthwhile venture for Gulf Oil Corporation.

During early development drilling stages of the Timbalier Bay field of South Louisiana, it was necessary to use new drilling fluid in each well for geological reasons. After sufficient geological information was obtained from a number of wells spaced throughout the field, thoughts were turned to the economic recovery of liquid muds for re-use in new drilling wells.

Several types of drilling fluids have been used in the field, viz. sea water lime, fresh water red, calcium chloride, and sea water-CMC (carboxy-methylcellulose) mud. The sea water-CMC mud is the most commonly used mud at the present time. This type mud has proved to be satisfactory, and is used in most wells drilled below 6,000 feet. The control of sea water-CMC mud requires the solids content to be maintained at relatively low values to obtain good flow properties. To obtain a low-solids content, sea water mud requires considerable dilution with water inasmuch as chemical dispersing agents have very little effect on viscosity control.

The dilution of high-density muds is a rather expensive means of controlling the flow properties of a mud system. Large quantities of surplus mud are built up in this manner. To combat the expense involved in diluting a high-density mud system with water and adding barites to maintain a desired density, the separation and recovery of barites from undesirable formation solids by mechanical separation is a necessity if reasonable mud costs are to be obtained. Additionally, if some means of storing and transferring sur-

plus quantities of mud from a drilling well's mud system for reuse in other drilling or workover operations is available, savings in overall field mud costs can be made. With these thoughts in mind, Gulf Oil designed and equipped an inexpensive mud-reclamation system for Timbalier Bay field.

Components of reclamation system. The mud-reclamation system in use in the Timbalier Bay field consists of four components:

1. In the early part of 1956, a 110-foot by 30-foot by 7-foot cargo barge was equipped with three 250-barrel capacity oil storage tanks, a 40-hp positive-displacement double-acting pump, powered by a diesel engine, and necessary suction and discharge manifolds. The pump serves three purposes, viz., transferring liquid mud to and from a rig, agitation of mud in each of the storage tanks through nozzles, and as a washdown pump. The barge was equipped for $13,134. This figure does not include the cost of the barge. This barge will be referred to as the transfer barge.

The purpose of the transfer barge is to store liquid mud received from one well for reuse in other workover or drilling wells. No treatment, other than agitation of the mud to prevent settling, takes place on the barge. If the mud requires treatment prior to reuse, this must be accomplished in the drilling or workover-surface mud systems.

2. During the latter part of 1956, a second cargo barge of the same dimensions as the transfer barge was equipped with one 750-barrel capacity fabricated steel storage tank, with two 7½-hp electrically powered stirrers, one 250-barrel capacity fabricated steel storage tank with one 7½-hp electrically powered stirrer, a single-screw rotary pump powered by a 50-hp diesel engine, a 40-kw generator set, a 2-hp light plant, a 2-hp centrifugal water pump, and a hydraulically powered decanting-type centrifuge with necessary hydraulic and mud lines. The barge was equipped for $42,952, excluding the cost of the barge. This barge will be referred to as the reclamation barge.

Figure 1 shows a schematic flow diagram of the barge.

The single-screw rotary-type pump was selected for use on the reclamation barge because large-sized granular particles, such as walnut shells, can be pumped without damage to the pump. The pump is powered by a 50-hp diesel engine through a 3:1 reduction gear. The pump is capable of delivering 450 gallons per minute at 600 rpm and 150 psi pressure.

The pump serves as a transfer pump with the added feature of being able to spot a concentrated slug of walnut shell and mud slurry inside drill pipe for pumping down the drill pipe to seal off zones of loss circulation.

A hydraulically-powered decanting-type centrifuge is mounted on top of the 250-barrel capacity mud-storage tank. The purpose of the centrifuge is to separate barites from low-density drilled formation solids. The barites are recovered for reuse while the low-density formation solids are discarded.

While the barge is being used for treating a rig mud system to recover barites, the barge is tied along side the drilling rig near the mud tanks. One hundred barrels of mud are pumped from the rig mud system into the small storage tank on the barge. This volume of mud serves as a medium to receive and dilute the barite sludge coming from the centrifuge to the desired density before pumping back to the active mud system.

A 2-inch, rubber suction hose is connected between the active mud tank to a small single-screw rotary pump on the reclamation barge. The mud is picked up from the active mud pit and pumped to the centrifuge. Before the mud reaches the centrifuge, it is diluted with bay water, whereby a more efficient separation can take place in the centrifuge. The barite sludge drops into the mud tank and is further diluted with water until the desired density is obtained. A third single-screw rotary pump delivers the treated slurry from a small tank on the barge to the active suction pit for reuse.

The effluent from the centrifuge, containing undesirable formation solids, water, chemicals, and oil, flows by gravity to a receiving tank on the drilling barge.

The operation of the barge in the foregoing manner becomes a continuous operation when all pumps delivering mud and water are regulated to maintain a constant level of mud in the 250-barrel tank.

The centrifuge can be used to maintain the mud at a constant density if only the removal of formation solids to reduce viscosity is desired. Or, the density of mud in the active mud system can be increased several points of weight by proper regulation of dilution water, without addition of dry barites.

Another feature of the barge is that surplus mud from the 750-barrel storage tank can be treated in the same manner as mud received from an active mud system. This becomes an important feature when a well has experienced loss of circulation. The barge can be towed to other rigs operating in the field and take on any excess volumes of mud they might have. The surplus mud is treated by use of the centrifuge, if need be, and delivered to the rig needing a volume of mud.

The barge is also used to store and transport mud from rig to rig within the field or other nearby fields as needed.

3. A hydraulically powered decanting-type centrifuge has been mounted on a large drilling rig as a stationary installation. The drilling rig is being utilized to drill deep wells which require the use of high-density muds in the range of 16.5 ppg to 17.8 ppg. The pump suction feeding mud to the centrifuge is movable and can be placed in the active mud tank or either of the rig's reserve mud tanks. By this feature, the mud in the active mud system can be treated to reduce viscosity and gel strengths or barites can be separated from reserve mud for reuse in the active system to increase the mud density.

4. A canal dredged into the island and dammed up serves as a disposal pit. The disposal pit is used only when discarding surplus low density muds and mud deemed unfit for further use.

Advantages and disadvantages. The reclamation system has been in service in the Timbalier Bay field for more than a year. Economic advantages are:

1. The salvage of all useful mud.

2. The ability to furnish mud to wells at predetermined densities.

3. Reduction in rig time spent mixing and conditioning mud.

4. Reduction of over-all mud and chemical costs.

5. Available supply of ready-to-use mud in emergencies.

6. Reduction in amount of dry mud and chemicals stored at the rigs.

7. Reduction in the number of boat trips to the field to deliver chemicals.

8. Better control of mud disposition and costs.

Disadvantages are:

1. Increased investment.

2. Requires more tug-boat hours to handle liquid-mud barges.

3. Additional equipment to secure and maintain at the rigs.

4. Additional equipment to pull in during storms.

5. Necessitates the use of one type mud only.

6. The transfer of fossils may be objectional from one field to another in wildcat operations.

7. Requires additional personnel.

Uses of system. Many different uses have been found for the reclamation and transfer barges, and some of the more important are:

1. To furnish liquid mud of the desired density for workover operations. Since the mud barges have been put into service, workover mud costs have been cut to a bare minimum. Many workover operations are carried to completion without the purchase of any sacked materials.

2. Furnish volumes of mud when loss of circulation is encountered. By having ready-to-use liquid mud available much rig time spent mixing fresh volumes of mud is eliminated.

3. Removal of undesirable clay solids from a drilling well's mud system, thereby reducing gel strengths and viscosities by means other than dilution.

4. The centrifuge units have been used to increase the density of a mud system several points of density, without the addition of dry materials.

5. Both barges have been used to transport excess volumes of low-density muds to the disposal pit.

6. The barges have been used to store large quantities of high-density muds while moving a drilling rig off location and a workover rig on location for the completion of a well. The barges have been used in this manner on many occasions. Without the facilities to store high-density muds, it would be prohibitive to move workover rigs on location for the completion of deep wells. The expense required to build fresh volumes of mud for this purpose would be great. Additional drilling rigs at a more expensive day rate than workover rigs would be required to complete a year's drilling program if each drilling rig were required to complete the wells it drilled.

7. Volumes of high-density muds have been available for overcoming high formation pressures on controlled blowouts. An example of the reclamation barge used for this purpose was in one of the deep wells in the field. The well was drilled to a total depth with 17 ppg mud. A short 7-inch OD liner was hung and cemented at the bottom of the 9⅝-inch OD protective casing string. Prior to perforating the liner, the mud density was reduced to 12.6 ppg inasmuch as this density was used while drilling the interval to be perforated. Immediately after perforating the casing, a surface pressure of 1,850 psi was encountered. Failure of the wire line stuffing box necessitated the use of a blowout preventer to contain the pressure. To kill the well required the use of 1,050 barrels of 16.6 ppg mud. The reclamation barge had several hundred barrels of 16.6-ppg mud on board at the time. An additional 500 barrels of 16.6-ppg mud had recently been stored in the reserve pits of one of the drilling rigs. By having these volumes of mud available, the building of only a small quantity of fresh mud was required. An estimated $20,000 for mud and $2,000 for rig time was saved on this one job alone.

8. The reclamation barge has been used on one occasion to displace crude oil from the casing and tubing of a well with liquid mud prior to moving a workover rig on location. A hazard to safety was eliminated by having mud rather than crude oil in the well when moving the workover rig on location.

Economics of reclamation system. The two liquid-mud barges and the centrifuge unit installed on a drilling rig have effected large savings in the purchase of sacked mud and chemicals during the past 18 months. No effort has been made to evaluate savings in rig time accomplished by use of the reclamation system. However, considerable rig time has been saved in mud conditioning prior to making round trips because of the fact that the muds are maintained in better condition while using the centrifuge. The greatest rig-time savings have been made in cases of lost circulation where large quantities of mud are lost in the hole which normally require the building of fresh volumes of mud.

Considerable rig time has been saved on workover rigs which required large volumes of mud to displace oil and water from casing and tubing strings. In several cases, as much as 24 hours have been saved.

The reclamation barge, in one year's operation, has salvaged 36,000 barrels of liquid mud averaging 14.5 ppg. A conservative cost for a mud of this density is $12 per barrel. The centrifuge mounted on the barge has been used for 1,682 hours. A conservative recovery of 4,000 pounds of barites per hour can be made by use of the centrifuge.

The gross savings in mud purchases made with the barge are as follows:

36,000 barrels times $12 per barrel	$438,000
1,682 hours times 4,000 pound per hour times 0.0286 per pound	192,420
Gross savings	$630,420

The operating expenses for the reclamation barge amounts to approximately $5,000 per month. The operating expenses include barge and centrifuge rental, labor, maintenance, transportation, fuel and lubricating oils.

By calculation, the net savings effected by use of the barge have been $570,420 in one year. The transfer barge has been used to salvage 22,250 barrels of liquid mud averaging 12 pounds per gallon in one and one-half years of operation. A conservative figure of $5 per barrel has been assigned as the cost for 12 pounds per gallon mud. The gross savings realized from the use of the transfer barge has been $111,250.

The operating expenses for the transfer barge are approximately $1,000 per month. The expenses include barge rental, transportation, and maintenance.

By subtraction, the net savings realized from the transfer barge amounts to $93,250 in 18 months.

The centrifuge unit mounted on the drilling rig has reduced the over-all mud cost on one well alone by 36 percent over the preceding well drilled by the same rig and crews. An estimated $150,000 has been saved in the purchase of mud and chemicals during a seven-month period by use of the centrifuge mounted on the drilling rig.

Since operations commenced with each component of the reclamation system, a total net savings of $813,670 has been made in the Timbalier Bay field.

ACKNOWLEDGMENT

This article condensed from a paper, "Mud Reclamation—Timbalier Bay," presented before the spring meeting of the Southern Division of Production, API, Houston, February, 1958. The authors express appreciation to Gulf Oil Corporation for time allowed for the preparation of this paper.

FIGURE 1—The field technique used in applying thread-lock to casing joints consists of (1) removing the collars, (2) cleaning threads on both male and female members, (3) coating both threads with thread-lock, and (4) making the joint up to the normal amount, after which the joint can be lowered into the hole.

New compound developed for locking casing joints

Thermal-setting epoxy resin used like thread dope provides fast, economical method of preventing breakout of casing joints.

By Martin E. True and W. A. Pitts
Humble Oil & Refining Company, Houston

A TECHNIQUE and compound have been developed for use in locking casing joints to prevent disengagement of the lower section from the main string as drilling operations are performed below the casing. A thermal-setting resin especially compounded for this application is substituted for thread dope on the joints to be locked. Based on laboratory tests, this material produces a joint which has a greater resistance to breakout than that obtained by tack welding the made-up joints, the later being the accepted procedure by many operators. In extended field use this technique and material for locking casing joints are easily applied by drilling personnel and have effected an appreciable cost reduction by eliminating the services of a welder.

In the drilling, surface and protective casing strings are set and cemented to isolate formations and to minimize the possibility of stuck drill pipe as subsequent deeper drilling is carried out. Because the drill pipe rotates in a clockwise direction inside the casing, friction between the drill-pipe joints or rubber protectors acting against the casing applies a rotational force to the casing also in a clockwise direction. If this force is sufficient to overcome the combined resistance of the threaded casing connection and the friction or bond between the casing and the wall of the hole, it will cause the disengagement of the lower section of the casing from the main casing string.

In many instances, the disengaged portion of the casing string has moved downward in the hole and remains as an obstacle which requires that special care be taken as drill tools and pipe traverse this interval. With enlarged hole conditions below the point of disengagement, the loosened section of casing is likely to fall to one side to form an obstruction in the hole and block the entry of drill tools below this point. Even if the loosened section remains in relative alignment, the passage of drill tools is likely to damage and partially close the upper opening and prevent the drill bit from entering. In many case histories, this has resulted in the loss of the hole below the loosened section of casing, which has required either that the hole be sidetracked above this depth, or that it be abandoned completely.

Standard practice of many operators has been to tack-weld the lowermost casing connections, and some consider that three joints secured in this manner are adequate. Three equally spaced circumferential weld beads, 2 inches in length, applied at the juncture of the pipe and collar frequently are used in these field-welding operations. As is well-known, special precautions are required during the welding of alloy steel, particularly that type of alloy which is used in today's high-strength casing. When welding grade N-80 casing, it is considered essential to preheat the area adjacent to the weld to a temperature of 600° F. After the weld is completed, the area in the vicinity of the weld should be stress-relieved by post-heating to a temperature of 600° F. Then sufficient time should elapse for the pipe to cool to a safe low temperature before being immersed in well fluid. The heated portion of the casing should be protected from rapid cooling if performed under inclement weather conditions.

It is desirable that casing which has been heat-treated to obtain high strength should not be welded, particularly under oil-field conditions, because the application of such intense heat will change the characteristics of the steel. Embrittlement of steel is one alteration likely to occur, and this will reduce the impact resistance of the metal causing a condi-

tion which may result in failure. The difficulty of obtaining a dependable weld even during laboratory tests has emphasized the problem with which the oil-field operator is confronted inasmuch as welding under normal conditions, in general, is not conducive to the best results. Inspection of welds made both under laboratory and field conditions has revealed that small cracks are present in some of the weld beads immediately after cooling. This result is illustrated in Figure 2 which shows cracks which developed in a weld performed in the shop. These cracks form points of stress concentration which may lead to failure as drilling progresses.

Development of technique. In an attempt to improve on this phase of drilling oil wells, work was initiated for the purpose of evolving a technique for locking joints which would: (1) eliminate welding; (2) provide a simple method which could be used by the drilling crews; (3) be less expensive to use than welding; and (4) most important of all, permit the use of a method which can be applied with assurance that failures in the bottom casing joints will not be experienced.

Initially, it was assumed that it should be a relatively simple matter to add materials to the thread compound which would result in galling and subsequent freezing of the joint in attempted breakout. Based on laboratory tests this, however, was proved to be a false assumption in that introduction of various types of foreign material, such as hard grit and coarse iron filings, had relatively little effect on the torque to disengage joints. Materials which harden on setting, such as a mixture of glycerine and litharge, resulted only in a small increase in torque requirements for breaking out joints.

Mechanical interference was the next approach tested for locking joints and included various means of damaging threads, such as driving pins into made-up threads of the joints by powder charges. Casing collars were tapped as shown in Figure 3, for the various numbers and sizes of set screws with matching countersunk holes being drilled in threaded portions of the casing after joint make-up. Most of the methods tested resulted in some increase in the torque required for breaking joints, but all were below the minimum of 16,000 foot-pound required to break joints of 5½-inch casing which had been tack-welded in the laboratory. Since the breakout torque for tack-welded 5½-inch casing joints varied from 16,000 to 26,000 foot-pound, the higher value was selected as the goal for the minimum acceptable in the use of a new technique. The 5½-inch casing size was selected for laboratory investigation because the torque-measuring equipment, illustrated in Figure 4, lacked capacity for breaking casing joints of a larger size.

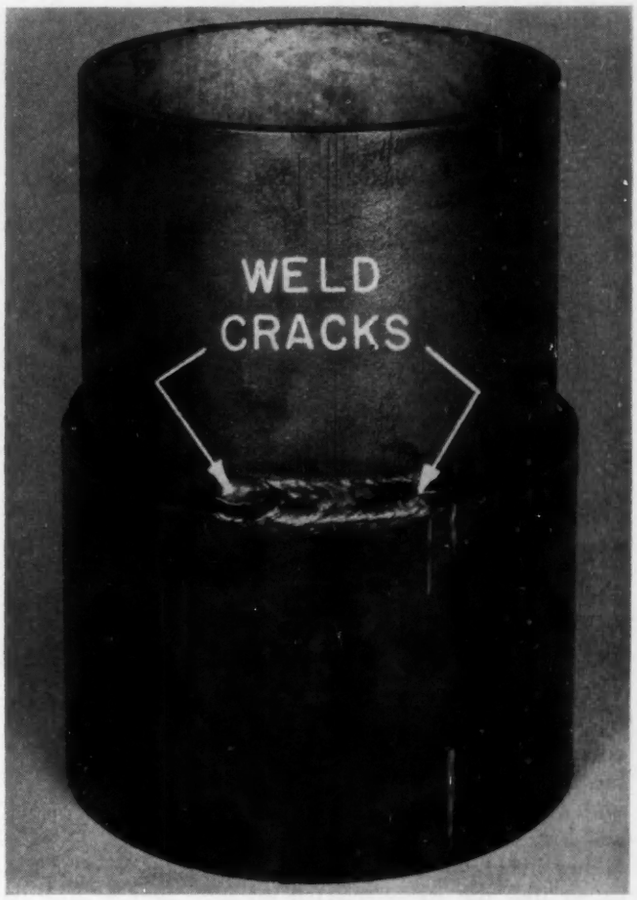


FIGURE 2—Typical crack in weld bead.

Encouraging results were obtained with commercially available thermal setting epoxy resins. It was determined by experiments that the addition of grit, such as aluminum oxide to the epoxy compound produced a joint which upon setting up, offered resistance to breakout consistently greater than the maximum obtained by tack-welding. Figure 5 shows the appearance of welded and epoxy-coated joints after being broken out and gives the relative torques required to break the joints.

Use of epoxy adhesives. The characteristics of thermal-setting epoxy compounds are affected by: (1) wellbore or curing temperature; and (2) the type and amount of accelerator or catalyst. Atmospheric temperature, which influences pot life and consistency of the material, can become a factor during the physical application of the material to the threads while making up the joint. The compound

FIGURE 3—Casing joint locked using set screw.

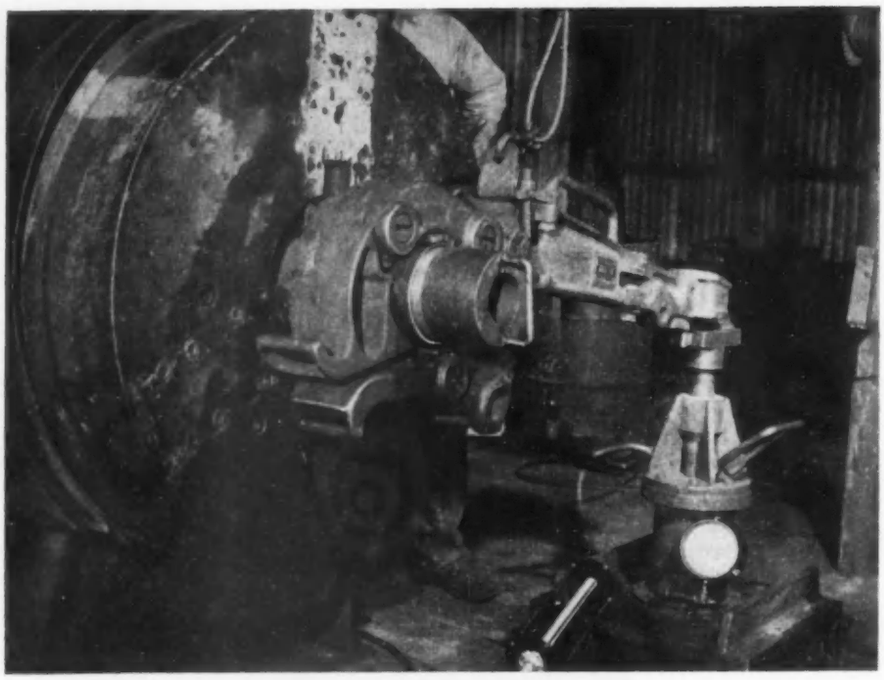


FIGURE 4—Torque measuring equipment.

currently being used on a routine basis has a pot life of about two hours under summer atmospheric conditions and longer under cooler temperature. It has been determined in the laboratory that the epoxy selected retains its bonding strength up to a temperature of 350° F. Occasionally, it becomes necessary to break out a joint in which the thread-lock material has set up. This can be accomplished with the application of heat by raising the temperature of the joint to 550° F., which will soften the material sufficiently to permit it to be backed out with approximately the torque used in the initial make-up.

Tests to determine the effect of various materials, such as grease, thread dopes, kerosine, and other cleaning solvents, revealed that grease and thread dopes on the thread, when the epoxy is applied, materially reduced the final strength developed in the joint. Kerosine or other solvents, however, appeared to have little effect on the bond formed between the metal surfaces by the epoxy resin.

The well-bore temperature is sufficiently great to provide the heat necessary to produce the thermal reaction to cause the bonding material to set in the time required for setting the casing string and waiting for the cement to set. The heat generated by the cement will accelerate the epoxy reaction.

This method and material for locking bottom casing joints have been used on 36 strings of casing, varying in size from 5½ to 13⅜ inches in diameter during the first five months that it has been under field tests.

ACKNOWLEDGMENT

This article taken from a paper entitled "Casing-Joint Thread Lock" and presented at the spring meeting API Southwestern Division of Production, Fort Worth, March, 1958.

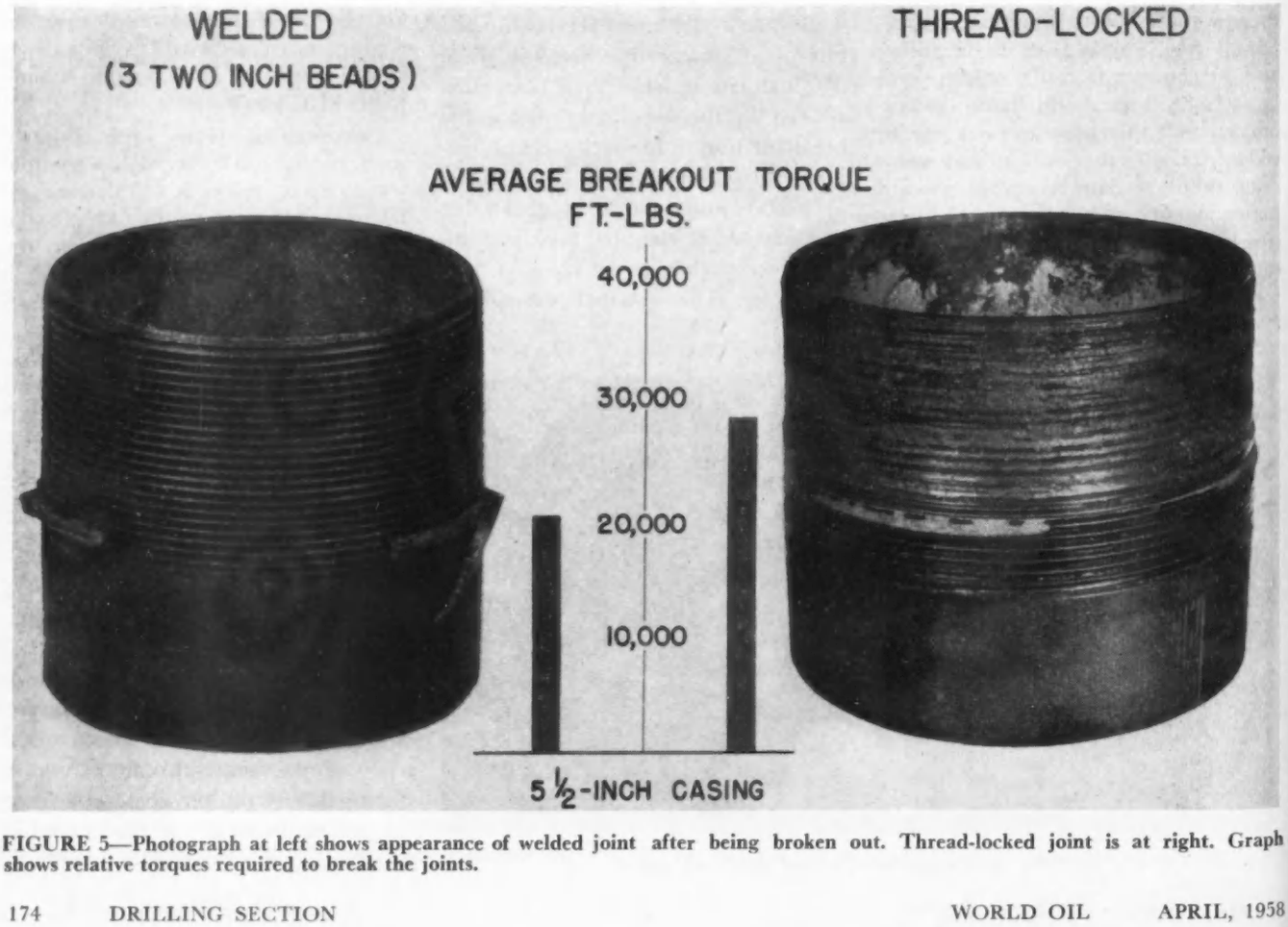


FIGURE 5—Photograph at left shows appearance of welded joint after being broken out. Thread-locked joint is at right. Graph shows relative torques required to break the joints.

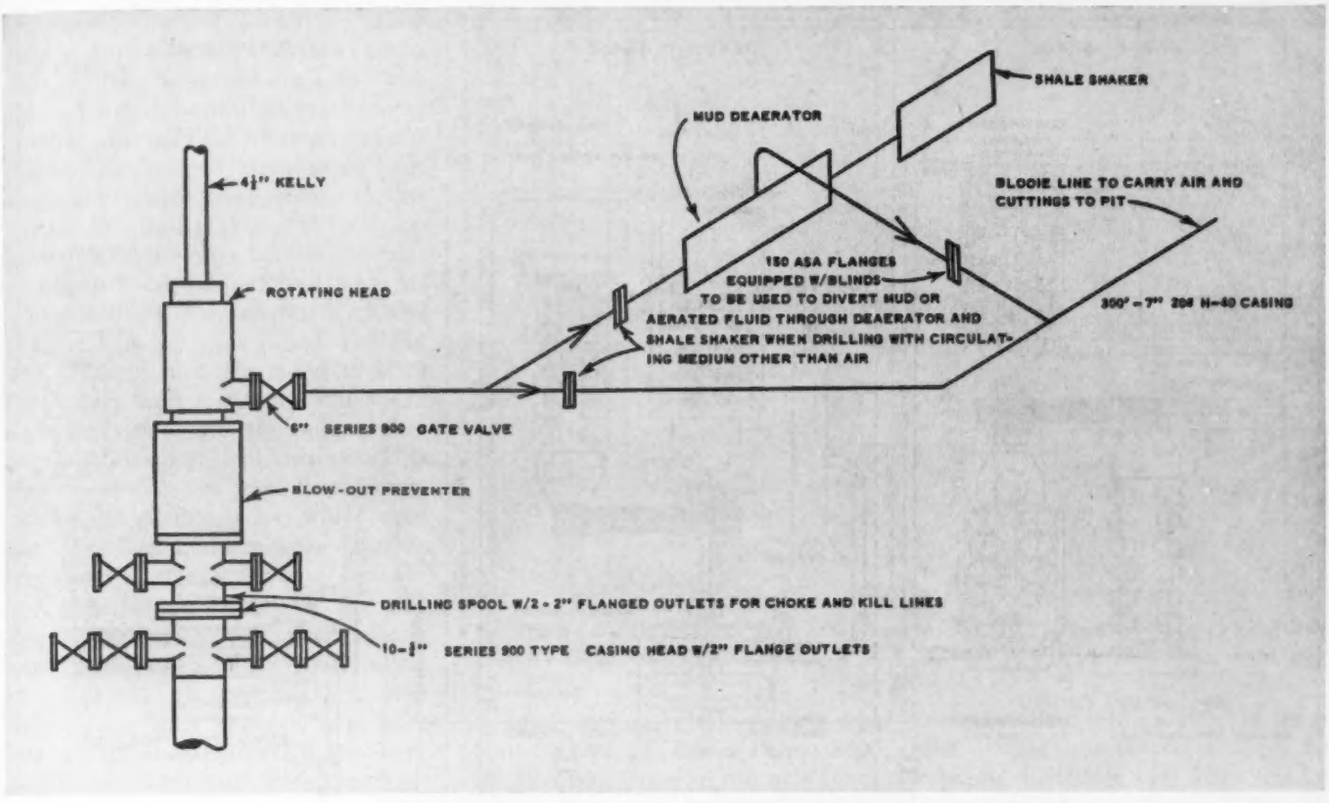

SHALE SHAKER
MUD DEAERATOR
4½" KELLY
BLOOIE LINE TO CARRY AIR AND CUTTINGS TO PIT
ROTATING HEAD
150 ASA FLANGES EQUIPPED W/BLINDS TO BE USED TO DIVERT MUD OR AERATED FLUID THROUGH DEAERATOR AND SHALE SHAKER WHEN DRILLING WITH CIRCULATING MEDIUM OTHER THAN AIR
350' - 7" 20# H-40 CASING
6" SERIES 900 GATE VALVE
BLOW-OUT PREVENTER
DRILLING SPOOL W/2 - 2" FLANGED OUTLETS FOR CHOKE AND KILL LINES
10-¾" SERIES 900 TYPE CASING HEAD W/2" FLANGE OUTLETS

FIGURE 1—Schematic drawing of drilling riser.

Shell cuts drilling costs

Use of air and aerated mud in Kentucky well spells $98,000 savings.

By T. W. G. Richardson
Shell Oil Company, Tulsa

BASED ON MUD drilling experience in comparable formations in the nearest well, a saving of $98,000 is reported by Shell Oil Company by application of air drilling techniques in a Kentucky wildcat test.

Comparing the mud drilling experience in one 400-foot interval an estimated saving of approximately $48,000 was made by use of air. The major source of this saving was reduced rig time and fewer bits.

Shell first became interested in air drilling of shot holes for seismic work in 1949. In 1952 the company undertook the air drilling and coring of the Bartlesville sand in a Canary field oil well, Washington County, Oklahoma.

First full scale air drilling operation, however, was the Davis 1, an 8821-foot wildcat well in the Tolu area, Crittenden County, Kentucky.

Reasons for selecting this well for air drilling were the extremely hard limestone and dolomite formations to be drilled and the strong likelihood of severe lost circulation of mud drilling. It was recognized that most previous air operations had been restricted to dry drilling, combatting lost circulation by injecting air into drilling mud, or other specialized applications.

Since fluid could be expected to be encountered in drilling the Davis 1, it was necessary to operate with equipment of sufficient capacity that fluid could be removed from the hole while drilling ahead with aerated fluid.

Drilling Rig. Conventional drilling equipment at the Davis 1 consisted of hoist driven by two diesel engines with torque converters rated at 233 horsepower each, a 136-foot mast with 8-foot substructure, pump, two engines, 4½-inch O.D. drill pipe and standard accessories.

Surface Connections. Surface connections or drilling riser consisted of casinghead, drilling spool with two flanged side outlets for choke and kill lines, blowout preventer and rotating head. The return line made of 7-inch O.D., 20-pound per foot, H-40 casing was connected immediately below the rotating head. (Figure 1).

Air Compressors. Air compressor equipment consisted of the following:

First Stage—Two compressors rated 2MMcfpd at 100 psig discharge and powered by 590-hp gas engine.

Second Stage—One compressor rated for 250 psig discharge and driven by 410-hp gas engine which also powered two intercoolers.

Third Stage—Two cylinder, horizontal gas booster compressor with one 4x11 and one 4½x11 cylinder

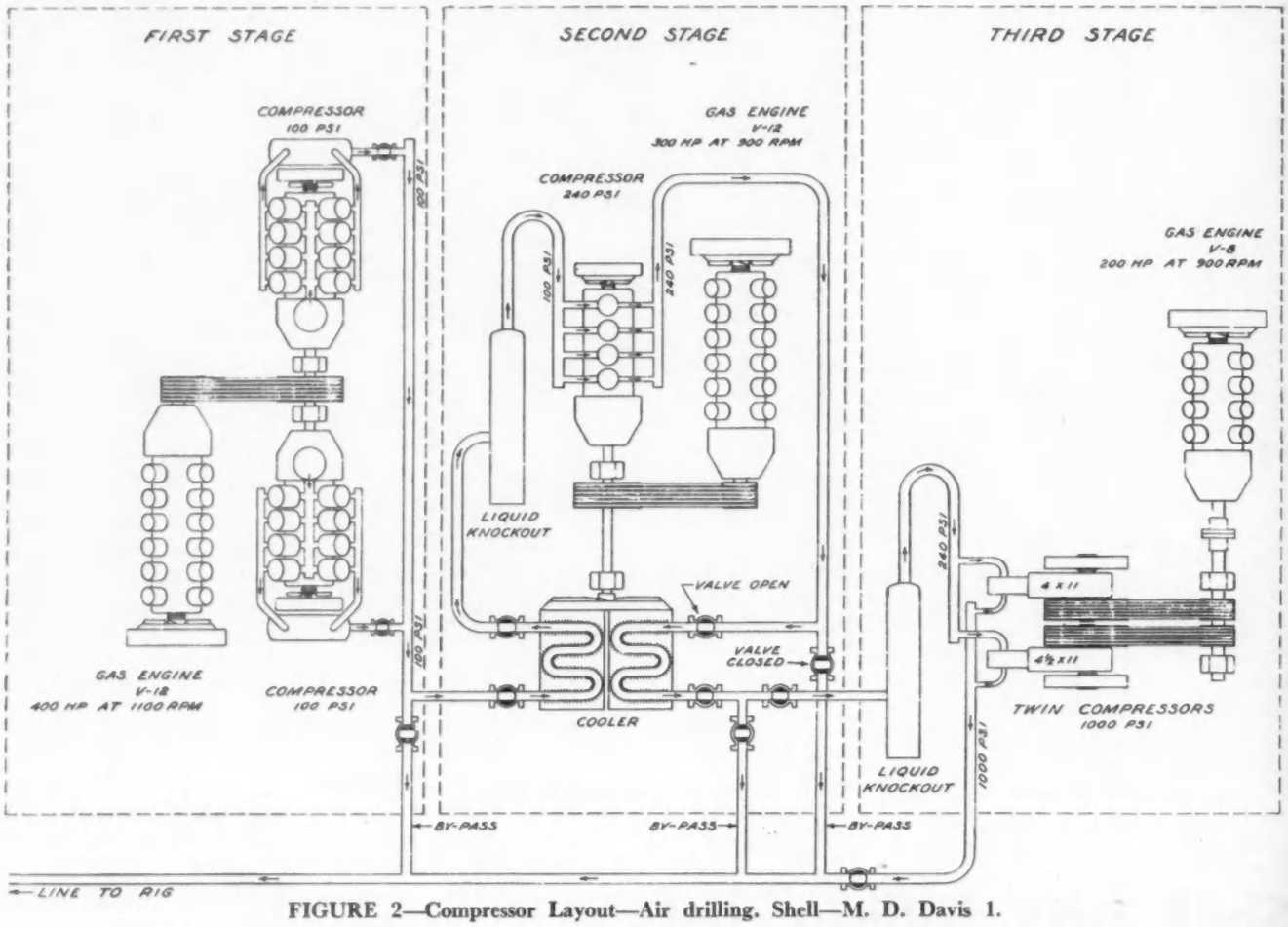


FIGURE 2—Compressor Layout—Air drilling. Shell—M. D. Davis 1.

rated for 1000 psig discharge and powered by 270-hp engine.

These heavy duty, continous service rated compressors were selected for their reliability and ruggedness and were well suited for the demands of air and aerated fluid drilling. It is notable that more engine horsepower was used to drive the air compressors (1270 hp) than was available on the drilling rig (932 hp). Figure 2 shows compressor layout.

Geology. The Tolu anticline is situated in the south-central part of the Illinois Basin. It is located within the mineralized fluorspar district and within a complex fault area. Surface expression of the structure is indicated as an inlier of Lower Mississippian beds surrounded by Upper Mississippian Strata.

Sediments range from St. Louis limestone of Lower Mississippian Age to Knox Dolomitic of Cambro-Ordovician Age. Mississippian sediments drilled, with the exception of Chattanooga shale, consisted primarily of hard, cherty, dolomite limestone with little or no porosity. Devonian and Silurian were predominantly limestone with a few thick dolomite sections. Chert content varied from 10 to 80 percent with the formations being dense and hard with little porosity. Ordovician formations, with the exception of Maquokata shale, consisted of dense limestone with chert content varying from five to 25 percent in the Trenton and Plattin and limy dolomite with no chert in the Joachim. The Ordovician formations, Dutchtown and St. Peter, were predominantly dolomite with thick sections of hard, tight, slightly porous sandstone. In the bottom of the hole, nearly 4000 feet of Knox Dolomite of Cambro-Ordovician Age was drilled. This consisted entirely of dense, finely crystalline, sandy dolomite with chert content varying from zero to 60 percent and containing a few sandstone stringers. Figure 3 shows geologic section drilled.

Drilling Summary. Due to the delay in delivering and assembling the air compressor equipment the well was spudded with mud.

Surface Hole (0-1532′, 8¾″ and 13¾″ Bits)—The surface hole was drilled in predominantly limestone and dolomite formations. Drilling conditions were very difficult and it was necessary to skid the rig after encountering a boulder at 39 feet in the first attempt to spud the well. In the second hole circulation was completely lost at 18 feet, and after setting a 16-inch conductor string at 47 feet, an 8¾-inch hole was drilled blind to 1532 feet using 21 bits in 14 days. While reaming the hole to 13¾-inch circulation was regained by using cement and lost circulation fiber. Fourteen days and 19 bits were required to ream the hole with water. Then a 10¾-inch casing string was cemented at 1481 feet and the blowout preventer and surface connections were installed.

Air Drilling (1532′-3950′ with 8¾″ Bits)—After rigging-up for air drilling the 10¾-inch casing was blown dry of fluid with 650 psig air pressure and cement was drilled out with 8¾-inch bit to 1532 feet. Air drilling of new hole commenced at this depth

with air circulation of 1400 cfm at 85 psig in limestone and dolomite. Good dust returns were obtained to 1800 feet, at which depth dust returns stopped and only air returns were obtained. By reverse circulation, cuttings and water were obtained and further circulation disclosed the presence of a small water flow of approximately two barrels per hour. An attempt to dry the water zone by blowing the hole with air failed. Drilling was resumed and continued to 3950 feet with frequent batching of 15-25 barrels of water into the hole to prevent balling up of drill cuttings. This was done with the idea that a hole can be drilled dry or wet but it cannot be drilled damp because of sticking the drill stem.

A detailed summary of air and aerated mud drilling experience is contained in Table 1. It is interesting to note that an 8¾-inch hole was drilled from 1805-3950 feet with 1400 cfm air after encountering the two-barrel per hour formation water flow. This water tended to form a paste with the cuttings and it was necessary to periodically inject 15-25 barrel slugs of water to remove the cuttings. Average drilling progress was 115 feet per day with an average of 143 feet per bit in predominantly limestone and dolomite formations with some zones containing up to 90 percent chert. Air drilling rate was 20 feet per hour and air-water drilling was about 10 feet per hour. Below 3300 feet shale sloughing in the hole made it difficult to keep the hole clean.

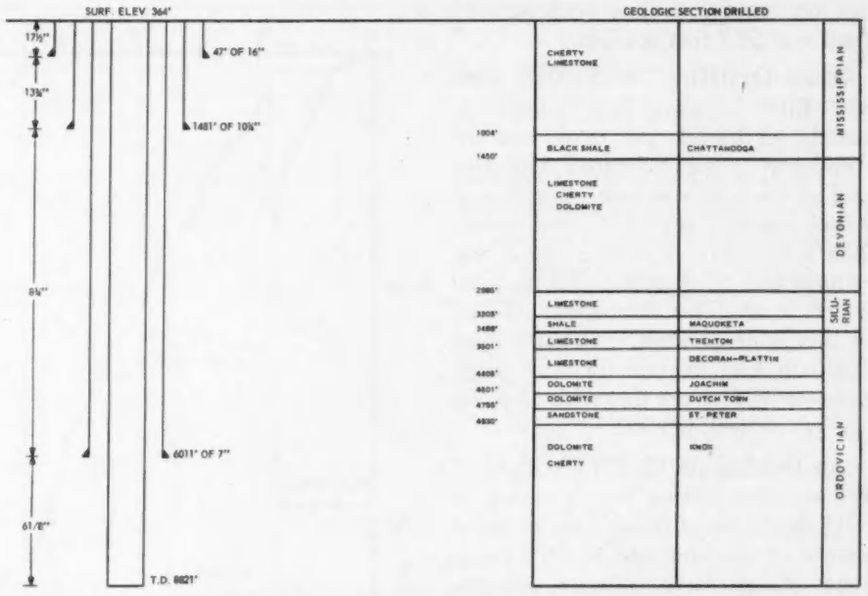


FIGURE 3—M. D. Davis 1, Tolu area, Section 17-L-16, Crittenden County, Kentucky.

Aerated Fluid Drilling (3950'-5613' with 8¾" Bits—At 3950 feet an excessive amount of time was being required to remove cuttings and keep the hole clean so aerated water was substituted for air. Approximately 1400 cfm air was used with 170 gallons per minute of fresh water saturated with lime to control drill pipe corrosion. The drilling progress shows that drilling was slowed considerably between 4000 feet and 5000 feet, as it was necessary to decrease the weight on the bit from an average of 30,000 pounds to 10-15,000 pounds to keep the hole deflection within reasonable limits. However, the over-all drilling progress in the limestone and dolomite formations was 80 feet per day and after the weight on bit was increased below 5000 feet, this was increased to 120 feet per day. Aver-

TABLE 1—Summary of Drilling Experience, M. D. Davis No. 1

Depth Interval	Circulating Fluid	Average Drilling Progress	Predominant Formations	Bit Size	No. Bits Including Those Used Only for Reaming	Bit Types	Best Footage/ Bit	Average Footage/ Bit	Formation Water Encountered	Average Pressure	Remarks
1532-3950' (2418')	Air 1400 CFM	115 ft/day	L.S.-Dolo. w/Chert Ranging 0–90%	8¾"	17	Carbide Insert	505'	143'	2 bbls/hr. 1805'	85-450 psi Varied erratically w/addn. of water.	After encountering formation fluid, removed cuttings by periodically adding 15-25 bbls. of fresh water.
3950-5613' (1663')	Aerated Fluid 170 gpm saturated lime water 1400 CFM Air	80 ft/day	L.S.-Dolo. w/up to 10% Chert in some intervals.	8¾"	25	Hard Rock	308'	66.7'	42 bbls/hr. from approx. 5500'	450-750 psi	Drilled w/reduced wts. from approx. 4200-5000 to straighten hole. Encountered formation wtr. @ 5500'. Mudded up 5613' to prepare for logging and run 7" casing at 6000'.
5613-6013' (400')	9.0# Fresh Water Mud	45 ft/day	Dolomite	8¾"	8	Hard Rock	93'	50'	.....	.....	Ran 7" casing 6011'.
6013-7975' (1962')	Air 1400 CFM	85 ft/day	Dolomite w/Chert and S.S. lenses.	6⅛"	22	Carbide Insert	221'	89.2'	Wtr. steadily increased from 12 gals/hr. @ 6091' to 34 bbls/hr. by 7700'. Increased to 64 bbls/hr. @ 7975'.	300-750 psi	Could not handle formation water flow of 64 bbls/hr. w/1000 psi air pressure; at 7975' converted to aerated water.
7975-8296' (321')	Aerated wtr. 150 gpm wtr. w/1400 CFM Air plus estimated 45 gpm formation wtr.	38 ft/day	Dolomite w/Chert and S.S. lenses.	6⅛"	8	Carbide Insert	109'	40'	Approx. 64 bbls/hr. entering drlg. fluid stream.	900-1000 psi	Could not maintain stable aerated column w/high water flow rate from formation.
8296-8821' (525')	Water	81 ft-day	Dolomite w/Chert and S.S. lenses.	6⅛"	11	Carbide Insert	123'	47.7'	.....	.....	.....

age bit footage drilling with aerated mud was 66.7 feet per bit.

Mud Drilling (5613'-6013' with 8¾" Bits)—A water flow of approximately 42 barrels per hour was encountered at approximately 5500 feet and as the hole was to be logged and 7-inch casing set at approximately 6000 feet, the circulating medium was converted to 9 pound/gallon fresh water mud. The formations drilled in this interval were essentially hard dolomite and average drilling progress was 45 feet per day with an average of 50 feet per bit.

Air Drilling (6013'-7975' with 6⅛" Bits)—After setting 7-inch casing at 6011 feet, air drilling was resumed with a circulation rate of 1400 cubic feet per minute. Water was encountered at 6091 feet and gradually increased from ¼ barrel per hour to 34 barrels per hour by 7700 feet. The air velocity in the smaller hole, up to 5600 feet per minute equivalent velocity, was apparently sufficient to remove both water and cuttings. Although drilling progress was slowed the first few days due to installing rubber protectors on 6000 feet of 2⅞-inch drill tubing, and a faulty weight indicator, average progress was 85 feet per day with an average of 89.2 feet per bit. The formations were predominantly dolomite with chert and sandstone lenses.

TABLE 2

Cost Comparison—Air and Aerated Mud vs. Mud Drilling Based on Drilling Rates—St. Joseph Lead Company—Hamp No. 1

	As Drilled*	Mud
Drill Site	$ 1,800	$ 1,500
Moving Expense	8,000	6,500
Rig-Up	8,000	3,500
Rig Time and Bits		
Surface (0-1532')		
Water		
28 days @ $850/day	.....	23,800
21—8¾" @ $185 each	.....	3,885
19—13¾" @ $371 each	.....	7,049
Air		
21 days @ $850/day	17,850	.....
11—8¾" @ $185 each	2,035	.....
11—13¾" @ $371 each	4,081	.....
8¾" Hole (1532-6018')		
Mud		
153 days @ $850/day	.....	130,050
19—8¾" Bits @ $1,103 each	.....	20,957
70—8¾" Bits @ $185 each	.....	12,950
As Drilled		
51 days @ $850/day	43,350	.....
10—8¾" Bits @ $1,103 each	11,030	.....
37—8¾" Bits @ $185 each	6,845	.....
6⅛" Hole (6013-8821')		
Mud		
69 days @ $800/day	.....	55,200
32—6⅛" Bits @ $835 each	.....	26,720
24—6⅛" Bits @ $130 each	.....	3,120
As Drilled		
42 days @ $800/day	33,600	.....
23—6⅛" Bits @ $835 each	19,205	.....
18—6⅛" Bits @ $130 each	2,340	.....
Mud	3,000	10,000
Water	.....	5,000
Casing and Equipment	18,200	6,600
Cement and Service	8,000	8,000
Compressor Operator	6,000	.....
Compressor Rental	21,000	.....
Compressor Fuel	11,000	.....
Compressor Maintenance	400	.....
Compressor (Oil, Anti-Freeze, etc.)	800	.....
Total	$226,536	$324,831
Estimated Cost Reduction Using Air	$ 98,295	

* Except using air on surface.

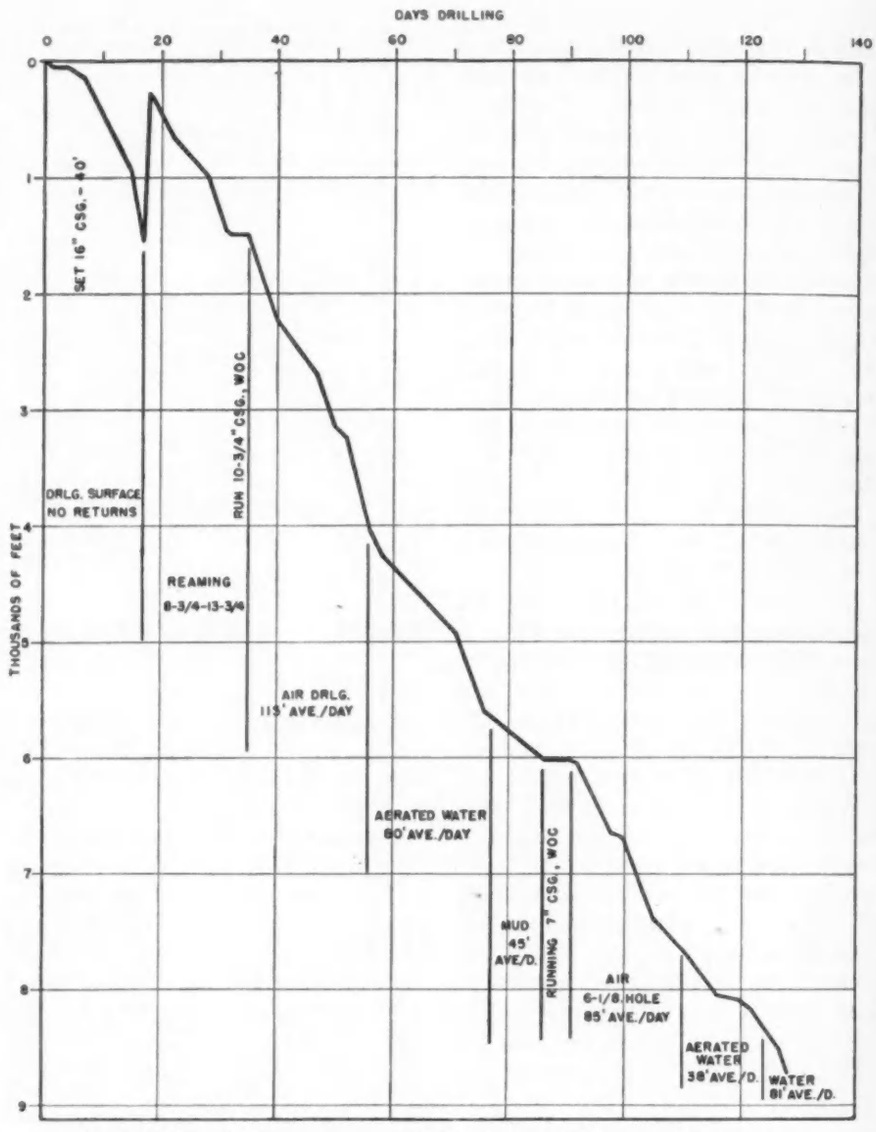


FIGURE 4—Drilling progress, M. D. Davis 1, Tolu area, Kentucky.

Aerated Mud (7975'-8296' with 6⅛" Bits)—Formation water volume increased to about 64 barrels per hour by 7975 feet and circulation could no longer be maintained with 1000 psi air pressure. An attempt was made to use aerated mud with 150 gpm water and 1400 cfm air. However, a stable aerated column could not be maintained, and bit life and drilling progress were reduced to 40 feet per bit and 38 feet per day. The formations were the same as those drilled from 6013-7975 feet.

Water (8296'-8821' with 6⅛" Bits)—Drilling progress in this interval was 81 feet per day with an average footage of 47.7 feet per bit. Although the average drilling progress compares favorably with air drilling in the interval 6013-7975 feet, and the formations consisted of the same material, they were not as difficult to drill because they were heavily fractured. The penetration rate on bottom was approximately 50 precent less with water than with air drilling.

At 8821 feet, the well was abandoned as unproductive.

Drilling Progress. To graphically illustrate drilling progress in Davis 1, a drilling-time curve has been prepared. (See Figure 4.) When well depth is plotted against drilling days the rate of drilling progress is apparent from the slope of the resulting curve and the various drilling techniques can be compared roughly. Notably air drilling is faster than

aerated fluid drilling which is faster than mud drilling.

Curves have also been prepared to compare air and aerated fluid drilling in Davis 1 with the mud drilling progress. (See Figure 5.) From the right in Figure 5, Curve 1 shows the mud drilling progress based on extrapolation of the nearest well to Davis 1. Curve 2 shows the mud drilling progress which would have resulted if the mud drilling rate in Davis 1 in the short interval 5613 feet—6013 feet had been obtained for the entire section. Dotted Curve 3 shows the actual progress made in Davis 1. The curve on the extreme left shows the progress that could have been expected if the surface hole had been air drilled. It is notable that Davis 1, as drilled, was 129 days faster than for mud drilling rates in nearest well.

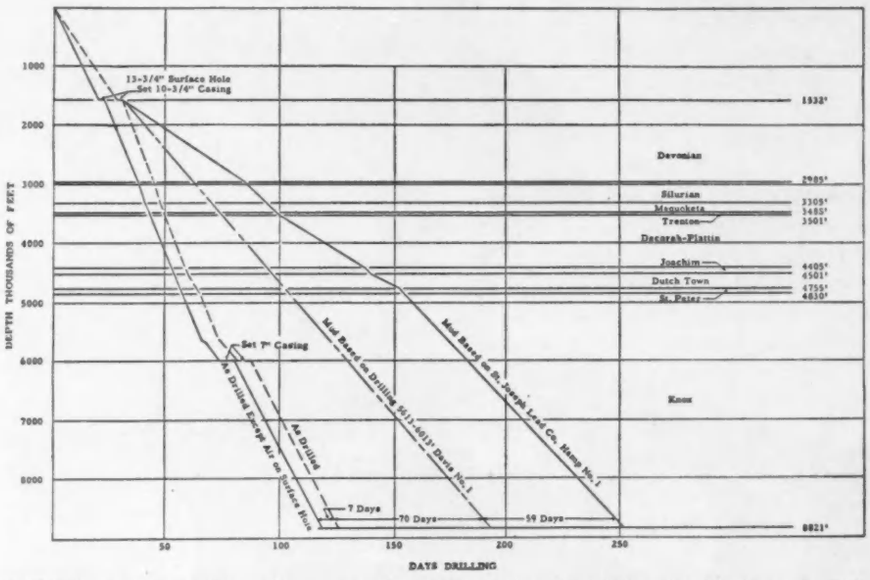


FIGURE 5—Comparison of mud vs. air and aerated mud drilling, M. D. Davis 1. Tolu area, Kentucky.

Cost Comparisons. In order to make an economic comparison of air and aerated fluid drilling with mud drilling, cost tabulations were prepared using operating costs for Davis 1 and the drilling progress curves previously discussed.

Mud Drilling—Nearest Offset Well—Comparison of cost, in Table 2, based on drilling experience in the nearest well which penetrated comparable formations, shows an estimated saving of approximately $98,000 by the use of air and aerated mud techniques in Davis 1. This well, St. Joseph Lead Company-H. Hamp 1, was drilled in Hardin County, Illinois, approximately 11 miles northeast of Davis 1 and was bottomed at 2948 feet, approximately 597 feet into the Knox dolomite. This comparison was made by applying the drilling progress experienced in Hamp 1 to comparable formations in Davis 1. The rig time and bit cost on the surface hole for mud drilling were obtained from experience in Davis 1 and the air drilling rates and bits are estimated from experience in the interval from 1532-3000 feet. Figure 4 shows that 129 days drilling time was saved by the use of air techniques in Davis 1.

The major sources of savings through application of air drilling techniques were in rig rental, $114,000, and bit cost, $29,000. The major items of additional expense in air drilling were rigging up costs, 6000 feet of 7-inch casing, compressor rental and fuel. It is estimated that $4000 rigging up expense could be saved by having piping and fittings unitized on the compressor skids. It will be noted that compressor maintenance was extremely low on this well, $1200, as compared to an estimated $4800 pump maintenance cost had mud been used.

Difficulty with lost circulation was experienced in Hamp 1 from approximately 230 feet to total depth and the well was finally abandoned before it reached its objective. The expenditure for mud in this well was approximately $25,000 and it is conservatively estimated that this cost would have been doubled if the well had penetrated 4000 feet into the Knox dolomite as did Davis 1.

Mud Drilling—Davis No. 1—Another method of comparison, Table 3 based on mud drilling progress from 5613 to 6013 feet in Davis 1 shows an estimated saving of approximately $48,000 by the use of air and aerated mud techniques where possible. The formations in this interval were hard dolomite but did not contain the chert and hard sandstone found in other intervals. It is therefore, felt that drilling rates in the St. Joseph Lead Company well are more representative over-all than those in the 400-foot interval drilled with mud in Davis 1.

TABLE 3

Cost Comparison—Air and Aerated Mud vs. Mud Drilling M. D. Davis No. 1 Based on Mud Drilling Rates (5613-6013')

	As Drilled*	Mud
Drill Site	$ 1,800	$ 1,500
Moving Expense	8,000	6,500
Rig-Up	8,000	3,500
Rig Time and Bits		
Surface (0-1532')		
Water		
28 days @ $850/day	.....	23,800
21—8¾" @ $185 each	.....	3,885
19—13¾" @ $371 each	.....	7,049
Air		
21 days @ $850/day	17,850	.....
11—8¾" @ $185 each	2,035	.....
11—13¾" @ $371 each	4,081	.....
8¾" Hole (1532-6013')		
Mud		
100 days @ $850/day	.....	85,000
19—8¾" Bits @ $1,103 each	.....	20,957
70—8¾" Bits @ $185 each	.....	12,950
As Drilled		
51 days @ $850/day	43,350	.....
10—8¾" Bits @ $1,103 each	11,030	.....
37—8¾" Bits @ $185 each	6,845	.....
6⅛" Hole (6013-8821')		
Mud		
63 days @ $800/day	.....	50,400
32—6⅛" Bits @ $835 ea.	.....	26,720
24—6⅛" Bits @ $130 each	.....	3,120
As Drilled		
42 days @ $800/day	33,600	.....
23—6⅛" Bits @ $835 each	19,205	.....
18—6⅛" Bits @ $130 each	2,340	.....
Mud	3,000	10,000
Water	.....	5,000
Casing and Equipment	18,200	6,600
Cement and Service	8,000	8,000
Compressor Operator	6,000	.....
Compressor Rental	21,000	.....
Compressor Fuel	11,000	.....
Compressor Maintenance	400	.....
Compressor (Oil, Anti-Freeze, etc.)	800	.....
Total	$226,536	$274,981
Estimated Cost Reduction Using Air	$ 48,445	

* Except using air on surface.

Conclusions

1. Based on mud drilling experience in comparable formations in the nearest well, a saving of $98,000 was made by application of air drilling techniques in Davis 1. Comparing the mud drilling experience in one 400-foot interval in Davis 1, an estimated saving of approximately $48,000 was made by use of air. The major source of this saving was reduced rig time and fewer bits.

2. The formation samples obtained while drilling with air or aerated mud ranged from dust to approximately one-half inch in size. While most of the samples could not

Continued on Page 185

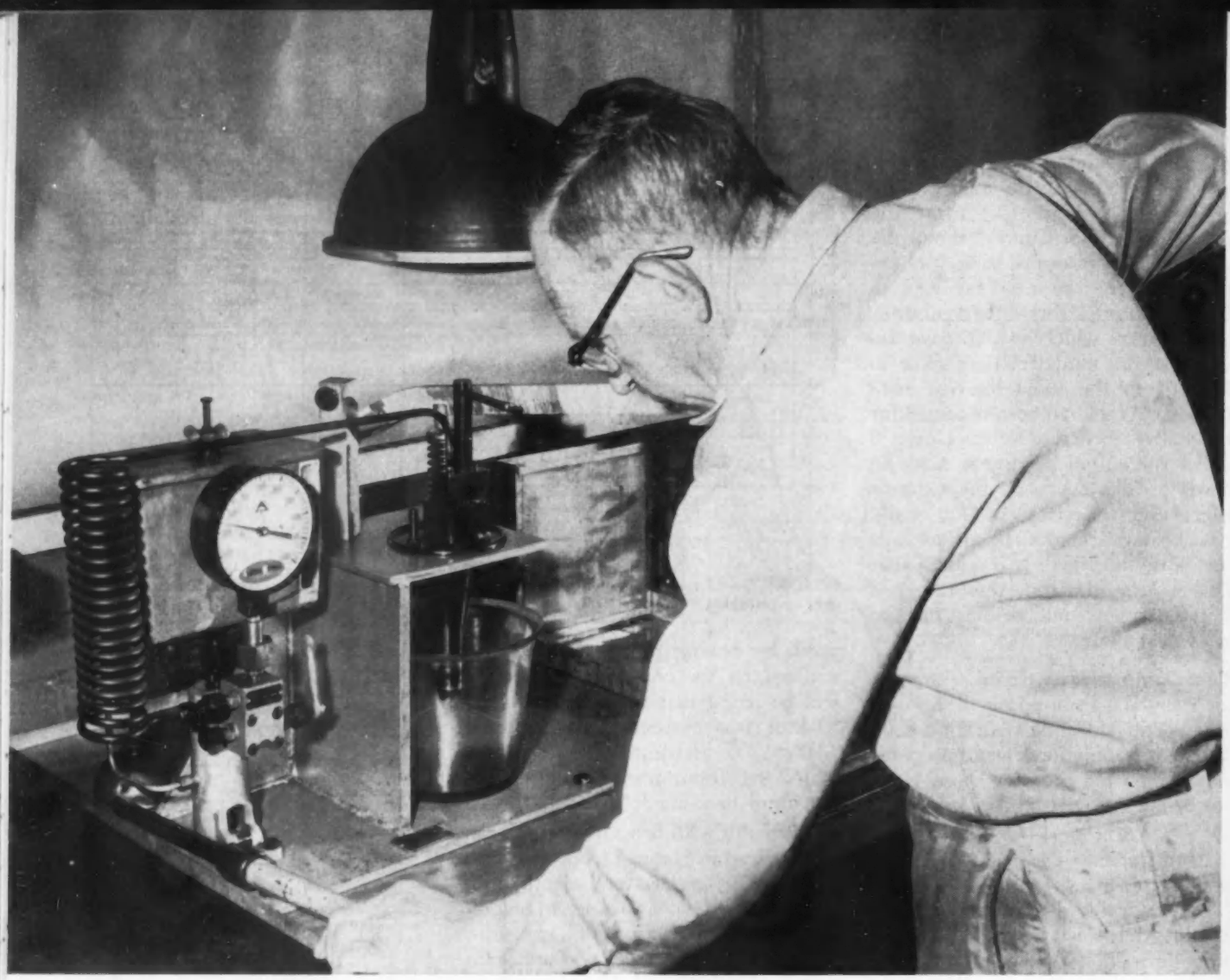


FIGURE 1—An inspector forces fuel through a nozzle at a predetermined pressure and checks the spray pattern for any irregular spray which would identify a defective nozzle. The pattern is visible through the glass receptacle. The black light installation can be seen just to the left of the inspector's head.

Diesel fuel injection patterns checked under black light

Diesel injector nozzle spray pattern can be observed better when fluorescent dyes and black light aid the inspector.

A SIMPLE and effective, faster and accurate bench test for checking the operation of fuel injectors on diesel engines recently was devised by the Southern Pacific Company. Fuel is forced through the nozzle and the resulting spray pattern is observed under black light. The black light causes the fuel to fluoresce, permitting the inspector to see the spray pattern which indicates any malfunction of the nozzles.

The injection pressure, volume of fuel injected and blocked or partially blocked nozzles are checked when the injector is put on the test bench. The injector introduces fuel into the cylinder at the beginning of the power stroke. The injector nozzle atomizes the fuel and spreads it evenly in the cylinder with sufficient penetration at the proper instant so that complete combustion of the fuel will occur. If the injector is not operating properly, in-

complete combustion occurs. If all fuel is not burned in the cylinder on the power stroke, power loss and dilution of the lubricating oil may result.

Dilution of the lubricating oil will reduce the lubrication quality of the oil on moving parts, causing excessive wear. Dilution is brought about when part of the fuel oil not burned in the cylinder slips past the rings into the lubricating oil reservoir, decreasing the viscosity of the lubricating oil and reducing its lubricating qualities. If the diluted oil is left in the engine, excessive wear and, eventually, seizures occur. This means that fuel injection is critical in obtaining maximum power and efficiency in operation of the diesel. Constant and careful maintenance checks are required for engines used in heavy field work. Maintenance of the injector should be done in the shop where equipment and space is available.

Adding a small amount of fluorescent dye to fuel oil used in the test makes the test more sensitive to the higher intensity black light. The fluorescent dye, when added to the oil, increases the fluorescent properties of the oil and the spray pattern can be readily observed under black light.

Black light is a popular term used to describe invisible radiation in the near ultra-violet range wave lengths. A special filter was used to eliminate almost all visible emission. There are no harmful effects to the eyes or skin. While black light is not new to the industry, the wide variety of detecting jobs it can do are not generally known. Its application to diesel fuel injectors offers a good example of how an existing test media can solve critical problems. **—The End**

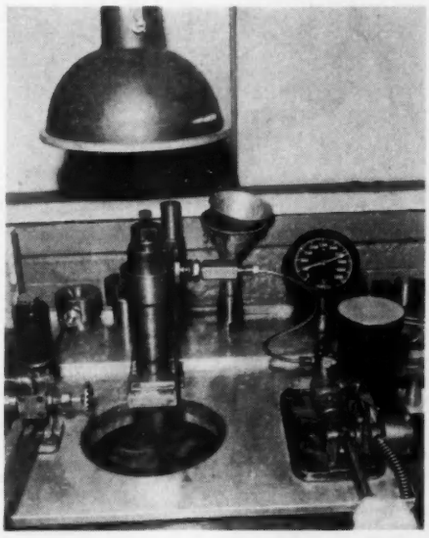


FIGURE 2—The spray pattern is easily seen with the aid of black light. Notice at the extreme ends of the jet streams the near vapor size droplets of fuel oil.

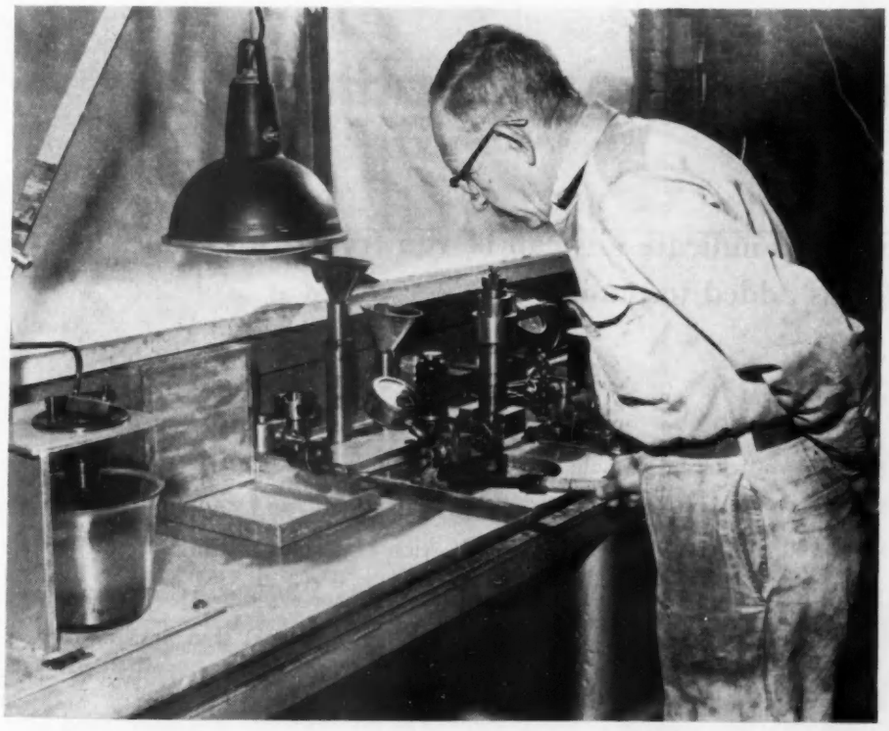


FIGURE 3—A different type of test is made on the nozzle with the jet stream just as easily seen as in the other test. Note the cleanliness of the bench. Cleanliness is very important in working with injectors because the very close tolerances of the metal to metal fits could be destroyed by very small fuzz, or the acid on the hand or finger.

Shell Cuts Drilling Costs

Continued from Page 179

be analyzed for physical characteristics, such as pore structure and fossil content, they were generally adequate for determination of lithology.

3. Varying amounts of formation water can be tolerated while air drilling depending upon air velocity, depth, types of formation, and disposal facilities. In Davis 1, water flows ranging from ¼ barrel per hour to approximately 34 barrels per hour were handled satisfactorily in the 6⅛-inch hole. The worst condition encountered was drilling 2100 feet of 8¾-inch hole after encountering a small water flow. It was then necessary to periodically inject slugs of water into the input air stream to remove the cuttings.

4. The major bit problem in air drilling with water in the hole appeared to be bearing life. As could be expected, bearing wear resulted in out of gauge hole. Approximately 90 percent of the tungsten carbide insert bits used in Davis 1 were pulled because of bearing failure.

5. In air drilling water bearing formations or in aerated fluid drilling, high pressure compressor equipment is necessary. Experience in Davis 1 indicated that compressors capable of operating at 1200 psi for short periods are needed.

6. Air volume requirements have been carefully analyzed and it appears that two MMcf per day is the minimum which can be efficiently utilized in the hole sizes and depths encountered in Davis 1. At least three MMcf per day can be used effectively in drilling an 8¾-inch or larger hole.

7. In hard formations such as encountered in Davis 1, air drilling materially improves both bit life and penetration rate. In this well, the maximum drilling rate was obtained while drilling dry formations and was approximately 400 percent better than mud drilling rates. In actual drilling progress, air drilling even with water in the hole was approximately 250 percent better than mud drilling in comparable formations. No valid comparison can be made with aerated fluid drilling due to crooked hole difficulties while aerated fluid was being used. **—The End**

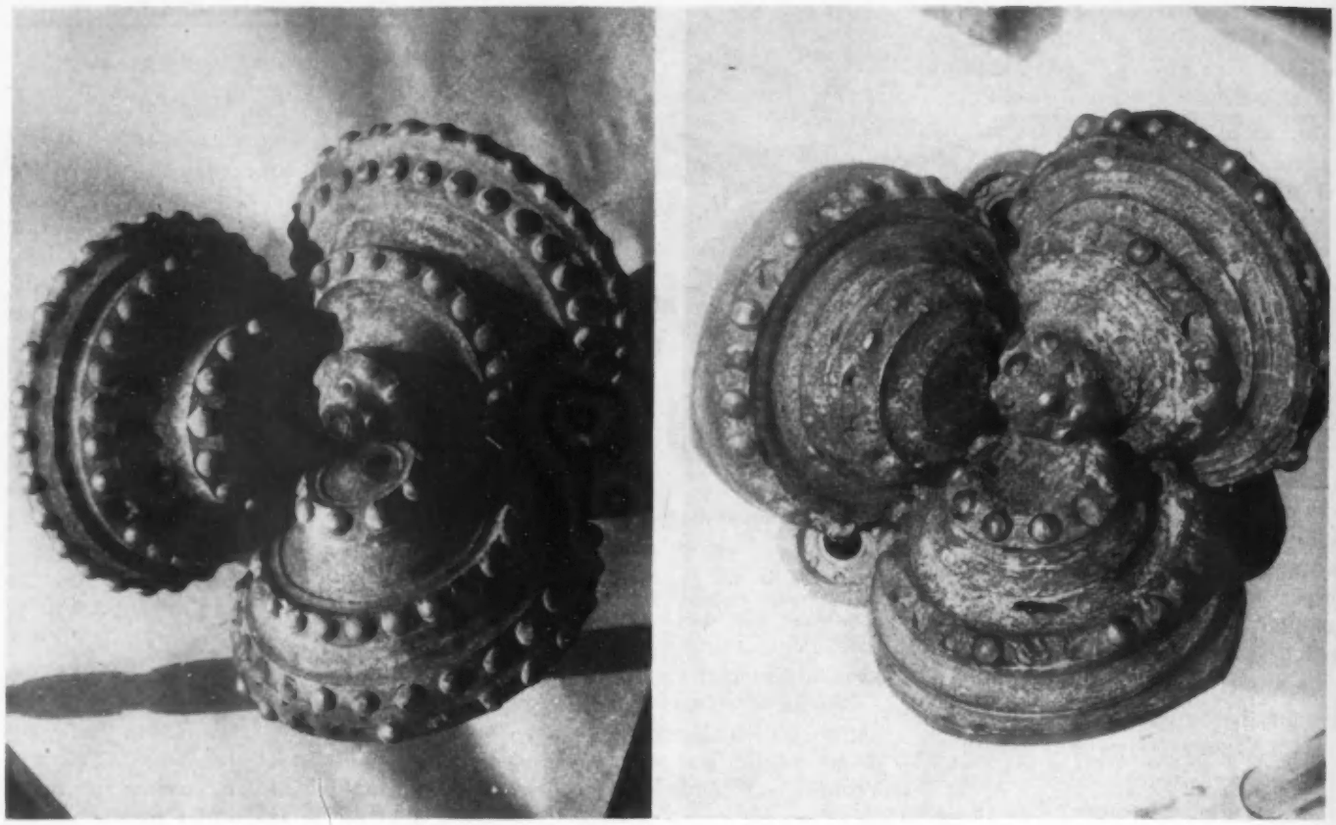


FIGURE 1—More than twice the penetration was obtained with bit on right, which ran until almost smooth with E.P. additives added to the drilling fluid, compared with bit on left used with the same fluid untreated by additives. Bearings locked on the non-E.P.-lubricated bit before its cutting potential was half used. The total footage made by bit at left was 504 feet, by bit at right 1,198 feet. Both are 8¾ chert bits run with 35,000-pound weight on bit at 35 rpm.

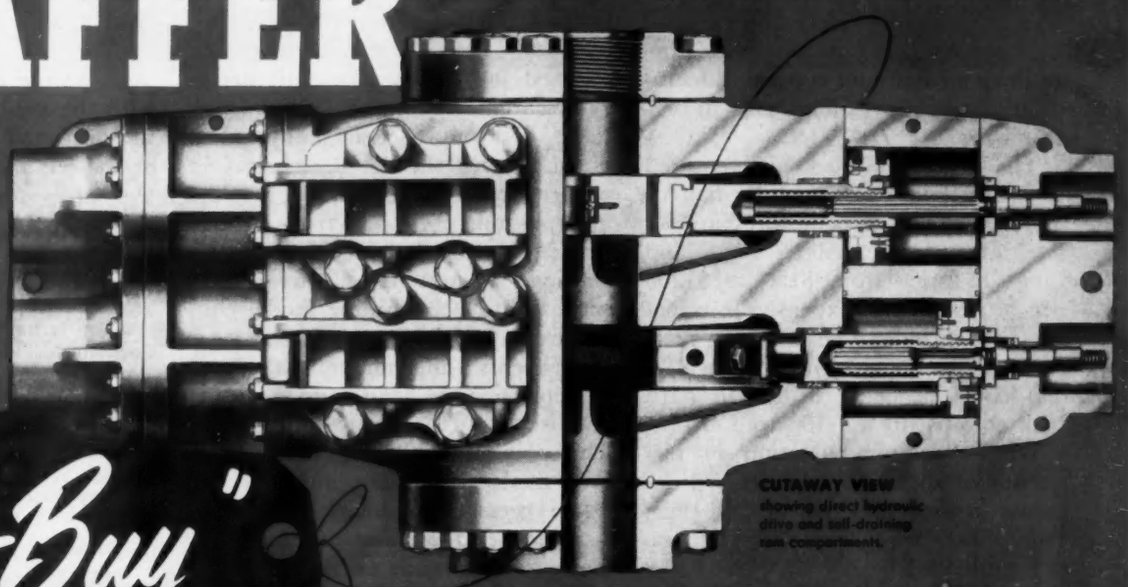
Lubricating mud additive extends bit life

Field and laboratory tests indicate bits can be run from 2 to 5 times longer when extreme pressure lubricant is added to mud.

RESEARCH ENGINEERS of Gulf Oil Corporation have developed a mud additive which promises to cut steadily mounting drilling costs, by reducing the time it takes to drill deep wells by as much as 12½ to 25 percent, and by extending the life of drilling equipment. The drilling fluid has extreme pressure lubricating qualities, which lubricate the drill bit bearing and the entire hole. Laboratory pilot tests under simulated field conditions and actual field tests have demonstrated the effectiveness of this new development. The company intends to share with the industry the benefits resulting from this product through licensing with the mud service organizations.

Research which led to the development was undertaken specifically to extend bit life by improving lubrication of the bit bearings. The extreme pressure lubricant additive used in the mud attacks that area of the bit most vulnerable to friction and heat. On the evidence of research and field trials, results indicate an increase in life of the drill bits by 2 to 5 times,

SHAFFER



CUTAWAY VIEW showing direct hydraulic drive and self-draining ram compartments.

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Backed by over three decades of pressure control leadership. Shaffer equipment is *quality* equipment, built throughout to the highest standard of safety, long life and low maintenance. It is the choice of leading operators throughout the oil world.

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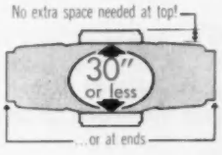
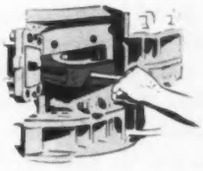


Even in sizes as large as 13⅝" (12" Series 900) Shaffer Hydraulic *Double* Gates (*two* ram compartments unitized into *one* compact body) require only 30" total height.

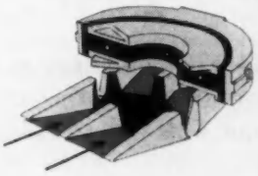
Width and length dimensions are also unusually compact... and no extra space is needed at the ends and top for ram changes!

They're CONVENIENT



Rams are changed through patented side-opening doors. And closing the doors automatically aligns the rams within the Gate. There's no need to dismantle the Gate to change rams—nor need extra space be provided above the Gate or at the ends in order to make ram changes!

They're SELF-DRAINING



Only Shaffer Gates provide *Self*-Draining Compartment Bottoms with rams traveling on high guide ribs where no detrimental sand or mud accumulates—another Shaffer feature that means better, *safer* performance whenever fast action is needed!

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34 years OF OIL TOOL LEADERSHIP

with a subsequent reduction in round-trips required to replace bits.

The lubricating properties of the additive to the mud system will substantially reduce drilling costs in several ways.

The number of rock bits required to drill a hole can be cut in half or more. Rock bit expenditures are an integral part of drilling costs and range in price from $150 to $1200 per bit, the more expensive bits being the carbide type used in hard formations. It is normal for a 10,000-foot well being drilled in hard rock country to use 100 to 150 bits.

With resultant reduction in frequency of round-trips, a marked decrease in wear and tear of drill pipe, tool joints, wire line and clutches, is experienced.

A slick-conditioned hole also is a decided advantage where the hole is crooked, or is intentionally being whipstocked.

Washover operations and fishing for pipe become less troublesome due to less friction. In this connection, the company reports that drill pipe rotating torque, measured on several test wells, using the lubricating additive in the mud, dropped as much as one-twentieth. Power requirements are lessened for turning the drill string.

Research workers at Gulf laboratories first approached the problem of improving the E. P. lubricating properties of drilling muds by the incorporation of additives which would properly lubricate drill bit bearings. To test the effectiveness of such additives in drilling muds, Gulf research engineers adapted for their experiments a machine normally used to determine the load carrying characteristics of E. P. lubricating oils. This was probably the first testing ever made of drilling mud for extreme pressure lubricating qualities.

Some 3,600 test runs of mud formulations were made on this machine, with results exceeding expectations of researchers. When E. P. additives were introduced, the loading carrying characteristics of the resulting mud mixture rose to surprisingly high values.

Encouraged by these experiments, researchers investigated further the implications of the first tests. A full-scale drilling rig was set up at the Gulf Research Center and pilot testing begun. Commercial bits were used, boring into steel blocks flooded with the mud under test. The results substantiated the findings with those of the test machine, revealing two to five times longer bit life with any drilling mud containing E. P. additives.

Specifically, the results were:

Conventional oil emulsion mud	20 life hours
Conventional oil emulsion mud with E.P.	60 life hours
Conventional 6% bentonite mud	10 life hours
Conventional 6% bentonite mud with E.P.	55 life hours
Conventional clay and water mud	15 life hours
Conventional clay and water mud with E.P.	65 life hours
Conventional weighted mud 11.5 ppg	38 life hours
Conventional weighted mud 11.5 ppg with E.P.	78 life hours

Next came the important field trials. In a comparative test in West Texas, a bit with conventional mud ran 17¾ hours and made 344 feet before failure, while in a similar formation nearby the same type of bit with the same mud plus E. P. additive, ran 41 hours and made 915 feet.

Other West Texas tests were made in harder formations with the tungsten carbide insert bits that are usually employed for this type of drilling. With E. P. lubricant added to the same muds under the same drilling conditions, the average bit life was extended about 75 hours, and one of the bits drilled 1200 feet in a hard dolomite formation.

After the E. P. trials, the used bits exhibited a condition seldom seen in the oil fields—instead of the teeth being in fair or good condition and the bearings bad, the reverse was true. The cones had been run until beaten smooth with the teeth ground down until hardly a cutting surface remained, but with bearings still good. Prior to the tests, it had been impossible to subject the teeth to such wear because of early bearing failure.

The E. P. additive is compatible with all present mud systems; the amounts to be used in the mud are relatively small and inexpensive.

—The End

The Knowledge Box

How well do you score?

A quiz for oil field folks. Score as follows: 0-4 (Weevil); 4-8 (Mud Doctor); 8-10 (Expert). One point for each correct answer. Answers at bottom of page.

1. **Which of the following is not a clay mineral?**
   a. Bentonite b. Attapulgite c. Barite

2. **An acid solution is in what pH range:**
   a. 0-7 7-14

3. **To convert from pounds per gallon to pounds per cubic feet, multiply by: a. 43.3 b. 7.5 c. 8.33**

4. **Barium chloride solution is added to mud filtrate to indicate the presence of: a. Calcium ion Sodium ion c. sulfate ion**

5. **Match the mud in one column with its base additive in the other column.**

a. Phosphate mud	**1. . . . . calcium hydroxide**
b. Saturated salt mud	**2. . . . . calcium sulfate**
c. Lime base mud	**3. . . . . sodium chloride**
d. Gyp base mud	**4. . . . . caustic-quebracho**
e. Red mud	**5. . . . . TSPP**

ANSWERS

1. c; 2. a; 3. b; 4. c; 5. 1,c; 2,d; 3,b; 4,e; 5,a.

Seeligson unit formed for secondary recovery

Unitized operation of 58 reservoirs should increase ultimate recovery by 60 million barrels of oil.

By John N. Schuelke
Associate Editor, Technical, WORLD OIL

THE CONSOLIDATION of the oil and gas interests of the Seeligson field into a single operating unit culminated nine years of geological and engineering work and should result in an increase of the ultimate oil recovery of 60 million barrels. This will be approximately 40 per cent more ultimate income from oil and gas, to the operators and royalty owners.

Geology of Seeligson field. The Seeligson field (Figure 1) lies on flat, mesquite-covered terrain with an elevation of about 150 feet above sea level. The surface formation is of the Pliocene age while the deepest formation penetrated to date is in the Jackson group of the Eocene age. The Seeligson field is one of several major fields occuring along the San Fordyce-Vanderbilt fault flexure and is similar in some respects to the structures of such fields as Rincon, Kelsey, La-Gloria, Borregas, Stratton, Agua Dulce, and others along this trend. The structure is a northeast-southwest anticline bounded on the west by the major Fordyce-Vanderbilt fault flexure.

Approximately 9 miles long and 4 miles wide, the field contains 14,-238.56 productive acres within the proposed unit boundaries. Development to date has revealed the existence of oil and gas bearing reserves in 27 zones above the 20C4 zone. These zones occur at depths ranging from 4,400 to 6,300 feet. All production from these zones and within the proposed unit area is from sands of the Frio age. The major fault controlled regional anticline controls the accumulation of oil and gas in this field, and this feature, coupled with sand pinch outs and variations in gas-oil and oil-water contacts, creates a wide diversity in reservoir and development problems from reservoir to reservoir.

The complexity of the reservoir studies was further aggravated by the three structural features which control the accumulation and distribution of oil and gas. The structural configuration of six of the larger and more representative zones is presented in Figure 2. Contours are representative of the top of the productive sand. Gas and oil productive areas are outlined. The following possibilities exist:

1. A single zone having three separate reservoirs (Zone 13-A), or
2. A single gas cap with a long thin oil rim (Zone 14-B), or
3. Three gas caps with one big oil rim (Zone 19-C), or
4. Shale outs or minor faulting that can cause three or four separate oil columns within one gas cap (Zone 18-C).

All of these type reservoirs occur in the Seeligson field. The hydrocarbon content of the various reservoirs ranges from all gas to all oil.

Production history. The Seeligson field discovery was Magnolia Petroleum Company's Seeligson 7 completed in Zone 22 on Dec. 6, 1937. It was located high on an anticlinal structure. No other oil bearing zones were proved by this well.

Five more wells were completed in Zone 22 by April, 1941. At that time, the discovery of oil in Zone 19C (on the flank of the large Seeligson structure) started an active drilling campaign and all zones above 24C were essentially developed by early 1950.

As of Oct. 1, 1957, there were 672 active wells in the entire field (all zones) 239 of which were dual completions, giving a total of 911 completions. Five hundred and eighty-eight of these wells or 794 completions are in sands 20C4 and above. Of the wells and completions in 20C4 and above, 464 wells and 637 completions are in the operating unit area.

The total Railroad Commission allowable as of Oct. 1, 1957, of the Seeligson field, is approximately 33,-651 barrels of oil per scheduled producing day. Of this, approximately 25,432 barrels per day are assigned to reservoirs 20C4 and above and in the proposed unit.

The combined production histories of all zones for the unit area are presented in Figure 3. As of Oct. 1, 1957, cumulative production from these zones (bottom of Table 2) and within the unit was 102,512,000 barrels of oil, 157,758,000 Mcf of casing-head gas, and 108,474,000 Mcf of free gas.

All reservoirs from which appreciable production has been obtained have undergone significant pressure drop. Gas-oil ratios have increased and water production to date does not indicate the existence of strong water drives.

Reservoir designations. Fifty-eight reservoirs occur within the Seeligson field unit above reservoir 20C-44 all of which will be included in the See-

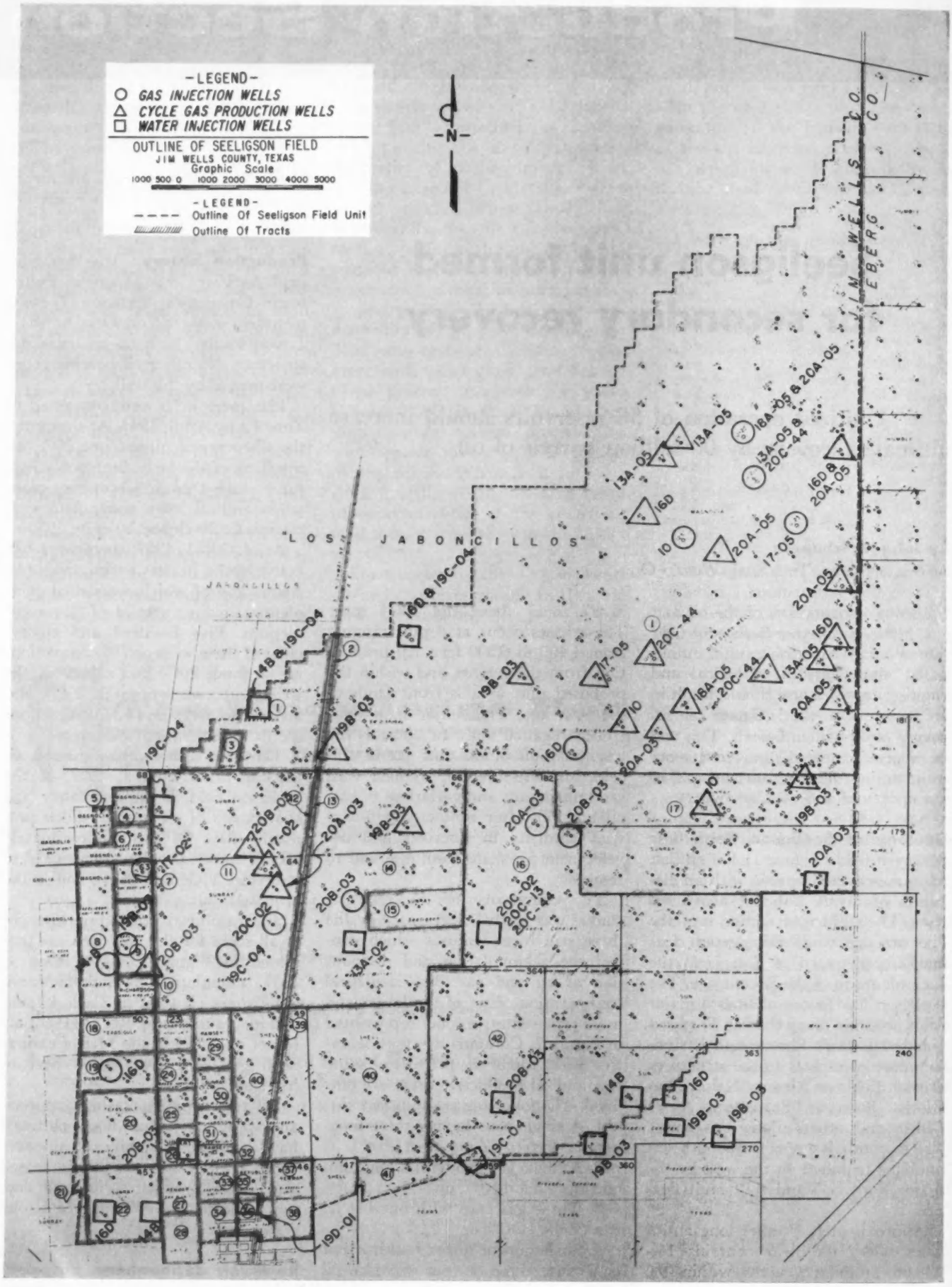


FIGURE 1—This plat of the Seeligson field is cut off in the Humble Oil & Refining Company's production in Kleberg County. The shaded area encloses the unit and each of the 42 tracts are indicated by a circled number. All of the presently proposed injection and cycling wells are indicated together with the reservoir that they will service.

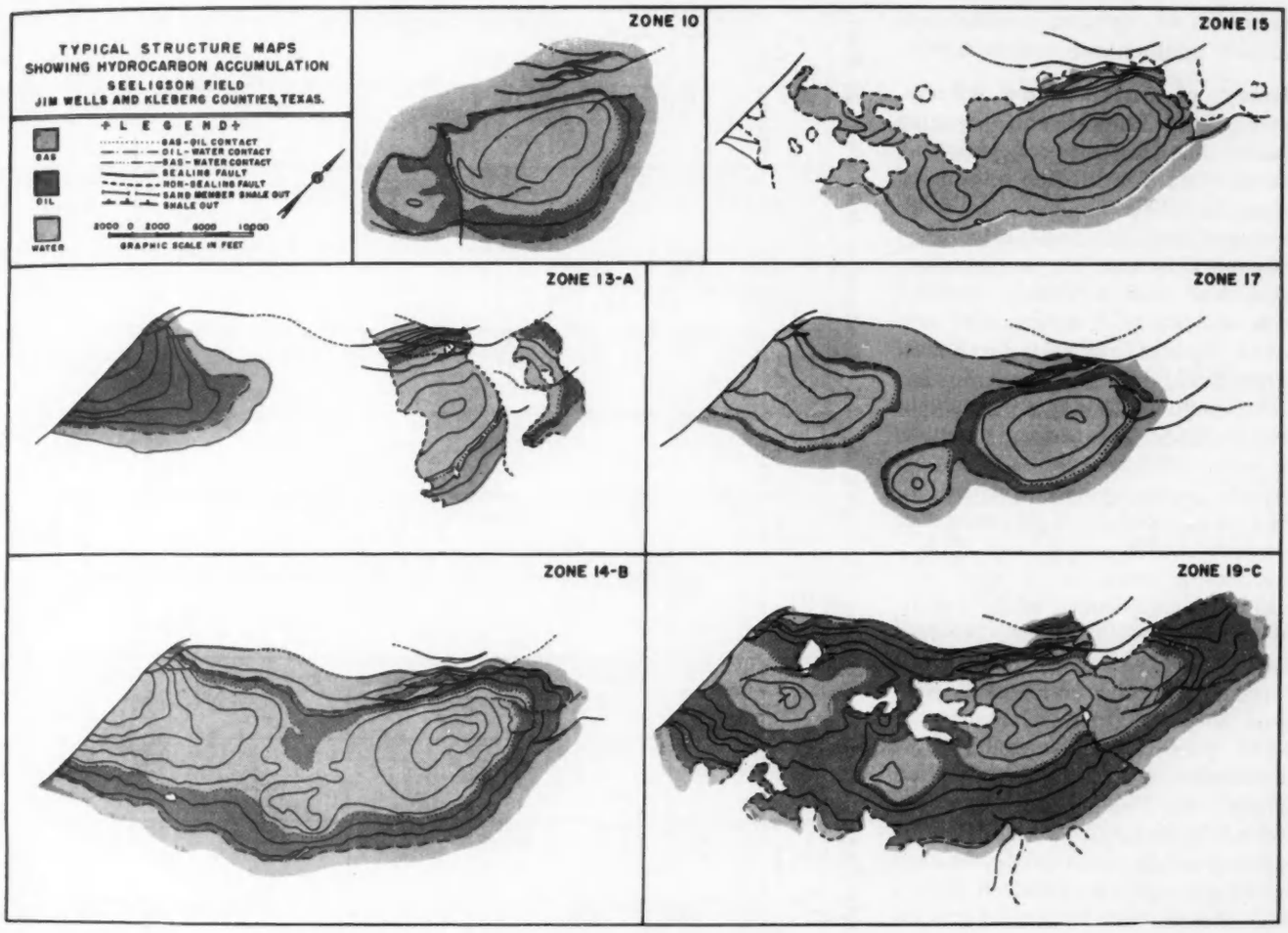


FIGURE 2—Here are six of the complex reservoir configurations that are encountered in the Seeligson field.

ligson field unit. Many of the non-associated gas reservoirs will be used for make-up gas production to supply unit needs. Figure 4 is a composite electric log of the field.

The various zones in the field have been named 9B, 10, 13A, 14B, etc. The sand members within a zone are designated as a numerical suffix to the zone, as; 20C-1, 20C-4, etc. Where sand members are lumped or are not separate within a zone the digit "0" is used as 13A-0 or 20C-0.

Where the oil and gas accumulations within a zone or sand have been separated into more than one hydrocarbon reservoir by faulting, pinchouts, or the complex configuration of the Seeligson structure the separate reservoirs have been indicated by a second numerical suffix to the zone and sand designations such as 13A-05 or 20C-44.

The reservoir suffix number roughly defines the geographic location of reservoirs within the field boundary; that is, one, indicates southwest portion and nine indicates northeast portion of the field.

General reservoir data. The oil-bearing area of these 58 reservoirs varies from 11 to 9,292 acres and the gas bearing area from 29 to 7,048 acres. All reservoir rocks are sandstone with average porosities ranging from 19.3 to 25.7 per cent, and permability from 40 to 705 millidarcys.

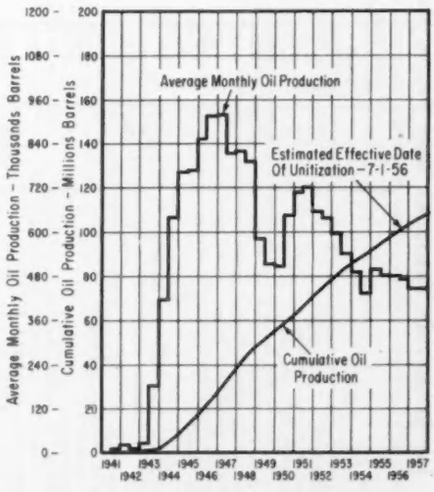


FIGURE 3—Monthly average and cumulative oil production from the unit area from the discovery date to the present.

Table 1 is a tabulation of the reservoir data of 18 of the 58 reservoirs in the unit, including structural features, physical properties of the rocks, reservoir fluid, pressures and temperatures, allowables and accumulative production. Core data was based upon the analysis of 8,931 routine samples and 259 capillary pressure samples. The correlations of various physical parameters and properties of reservoir fluids were based upon all available data and were used as a basis for making the best possible estimate for reservoirs from which actual measurements were not available. Correlations made include original reservoir pressure, temperature, formation volume factors, solution gas-oil ratios, visocsity, pseudo-critical constants, content of reservoir gases, and density of reservoir liquids and gases.

Extensive and comprehensive reservoir studies were conducted on all the major oil reservoirs. The analysis of the above data incorporated the use of Sun Oil Company's time analyzer and potentiometric model for

the design of optimum cycling and pressure maintenance programs.

History of unitization efforts. After World War II, the operators realized the necessity of gathering factual data for all the producing zones. In 1946, the Seeligson Engineering Committee was established with participation on a voluntary basis. Also during 1946, a detailed book of geological maps, was prepared by the Seeligson Geological Committee.

During June of 1948, a permanent, paid Seeligson Engineering Committee was established in San Antonio with the expenses shared proportionately to oil production by committee members. During 1948 and 1949, a considerable amount of work was done on the unitization of the gas interests in the field, including development of cycling plans, geological mapping, and construction of the Seeligson natural gasoline plant.

The present Seeligson Gas Unit was formed and placed in operation during 1948. The gas interests in the field were unitized on the basis of acre-feet of gas sand and liquid content of gas. All gas produced with a liquid content over 50 degrees gravity was considered to be unitized substance. Casinghead gas produced at ratios in excess of 1,000 cubic feet per stock tank barrel of oil also was credited to the gas unit participants. The Seeligson Gas Unit took over nine gas producing wells in July, 1948, and drilled 15 additional unit gas wells during 1948 and 1949. The present gas unit will be dissolved upon formation of the consolidated oil and gas unit and all production below zone 20-C4 returned to the lease owners.

An outside consultant was retained during the latter half of 1949 to assist the committee in oil unitization studies. He made preliminary reservoir studies in zones 13-A, 14-B and 19-D.

Electronic data processing equipment, to increase the efficiency of handling the large volume of Seeligson data, was installed in the committee offices in the spring of 1952.

In connection with oil unitization efforts, a year was spent in remapping all of the oil and gas bearing zones in the proposed unit area. This geological work was completed during July, 1953, and work was started on determining other formation and res-

TABLE 1—Reservoir Features and Properties—Characteristics of Reservoir Fluids and Production Statistics of 18 Reservoirs Included in Unit.

ZONE	10		13A-02		13A-05		14B		16D		17-02		17-05		18A-05		19B-03	
	Unit	Field	Unit	Field	Unit	Field	Unit	Field	Unit	Field	Unit	Field	Unit	Field	Unit	Field	Unit	Field
Content of Reservoir		Gas & Oil		Oil		Gas & Oil		Gas & Oil		Gas & Oil		Gas & Oil		Gas & Oil		Gas & Oil		Gas & Oil
Frac. of Res. inc. in Unit Area Gas		0.997				.995		0.994		0.993		1.00		0 999		0.994		0.955
Frac. of Res. inc. in Unit Area Oil		0.875		1.00		1.00		0.843		0 971		1.00		0.958		0.805		0.728
Productive Area, Acres—Oil	3,385	3,868	1,845	1,845	193	193	5,355	6,350	3,633	3,742	988	988	1,943	2,025	935	1,045	3,848	5,283
Productive Area, Acres—Gas	3,066	3,107			1,444	1,451	6,933	7,048	5,819	5,858	2,113	2,113	2,568	2,571	2,225	2,261	6,433	6,736
STRUCTURAL FEATURES:																		
Avg Water-Oil Content		4,529		4,759		4,897		5,093		5,412		5,395		5,403		5,551		5,996
Avg. Gas-Oil Content		4,505				4,863		5,036		5,331		5,385		5,380		5,531		5,768
Avg. Net Sand Thickness, Ft.		28.5		14.6		7.8		16.3		9.8		22.3		17.7		19.7		22.8
Orig. Ratio of Gas Cap. to Oil Sand, Volume		1.516				13.448		1.539		1.489		8.690		3.003		6,556		1.505
Type of Drive	1,881	Gas Cap. & Limited Water		Limited Water	13,434	Gas Cap. & Limited Water	1,884	Gas Cap. & Limited Water	1,509	Gas Cap. & Limited Water	8,690	Gas Cap. & Limited Water	3,146	Gas Cap. & Limited Water	7,955	Gas Cap. & Limited Water	1,832	Gas Cap. & Limited Water
AVG. PHY. PROP. OF RES. ROCKS:																		
Porosity, Percent		23.5		23.6		23.6		25.2		21.6		22.4		22.4		23.9		24.1
Permeability, md		313.0		208.0		208.0		423.0		216.0		299.0		299.0		416.0		473.0
Avg. Interstitial Water Sat., Percent		32.9		32.5		33.5		30.0		31.9		33.1		32.7		32.3		26.7
AVG. ORIGINAL CHAR. OF RES. FLUID:																		
Oil Gravity, API at 60 °F.		39 9		36.1		36.1		37.2		40.9		37.8		37.2		42.1		41.1
Sat. (Bubble Point) Press., psig.		2,190		2,308		2,355		2,420		2,560		2,584		2,580		2,660		2,776
Form. Volume Factor		1.33		1.35		1.36		1.38		1.41		1.41		1.41		1.41		1.45
Viscosity, cp.		0 9421		0.4206		0.4121		0.3976		0.3721		0 3678		0.3680		0.3540		0.3329
Dissolved GOR, cu. ft./bbl.		580		619		635		662		708		716		715		741		780
Avg. Gas Content, gpm Propanes plus		1.31		1.41		1.45		1.51		1.62		1.64		1.64		1.68		1.74
PRESSURES & TEMPERATURES:																		
Orig. Res. Press., psig.		2,197		2,308		2,355		2,420		2,560		2,584		2,580		2,660		2,776
At Subsea datum (feet) of		4,523		4,759		4,863		5,036		5,312		5,385		5,376		5,531		5,728
Current Res. Press, psig.		1,874		1,025		1,946		2,041		2,022		2,419		2,572		2,583		2,122
Res. Temp.°F.		149		157		160		164		170		172		171		175		179
DEVELOPMENT AND ALLOWABLE STATUS:																		
No. of Prod. Wells, Oil	27	38	22	22	7	7	88	114	54	58	2	2	24	25	6	9	77	103
No. of Prod. Wells, Gas	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	0	0
No. of Penalized Oil Wells	24	34	5	5	6	6	71	81	35	37	2	2	16	17	5	8	26	29
No. of Inactive Wells	7	9	13	13	2	2	21	26	26	27	3	3	6	6	2	2	22	25
Top per Well Oil Allow., bbl./day	50	50	38	38	38	38	51	51	50	50	32	32	32	32	50	50	62	62
Daily Res. Oil Allow., Bbl.	527	821	580	580	121	121	2,247	3,281	1,609	1,734	20	20	429	433	125	152	3,887	5,395
STATISTICAL DATA: (7-1-57)																		
Cum Prod.:																		
Oil, Bbl		2,112,898		2,993,121		4,569,588		197,937		11,664,295		11,562,245		6,779,865		1,185,818		17,794,251
Gas, Mcf.—Oil Well		2,112,898		2,993,121		4,569,588		197,937		11,664,295		11,562,245		6,654,624		1,185,818		17,794,251
Gas Mcf.—Gas Well	6,334,718	7,793,353	6,253,167	6,253,167	414,831	414,831	28,310,928	31,063,150	1,716,227	1,716,227	20,000	20,000	43,568,149	43,568,149	63,169,729	63,169,729	16,846,338	19,758,700
Inj. Gas, Mcf.													47,914,494	47,914,494	66,743,622	66,743,622		
Water, Bbl.																		
Avg. Daily Oil Prod., Bbl.	252,400	266,576	553,467	553,467	3,323	3,323	616,451	730,217	574,748	626,978	15,559	15,559	140,311	145,584	106,619	117,319	432,079	713,930
Avg. Prod. GOR, cf/pb	243	410	313	313	64	64	1,246	1,785	801	875	16	16	255	257	75	90	1,955	2,718
	5,970	5,015	1,120	1,120	3,050	3,050	4,460	3,390	3,100	3,007	8,750	8,750	3,565	3,570	6,900	7,760	1,645	1,504

ZONE	19C-04		19D-01		20A-03		20A-05		20B-03		20C-02		20C-13		20C-15		20C-44	
	Unit	Field	Unit	Field	Unit	Field	Unit	Field	Unit	Field	Unit	Field	Unit	Field	Unit	Field	Unit	Field
Content of Reservoir		Gas & Oil		Gas & Oil		Gas & Oil		Gas & Oil		Gas & Oil		Gas & Oil		Oil		Gas & Oil		Gas & Oil
Frac. of Res. inc. in Unit Area Gas		1.00		1.00		1.00		0.599		0.991		1.00				1.00		1.00
Frac. of Res. inc. in Unit Area Oil		0.878		1.00		1.00		0.210		0.950		1.00		1.00		0.939		0.985
Productive Area, Acres—Oil	8,162	9,292	2,078	2,078	1,687	1,687	140	668	3,173	3,339	1,708	1,708		393	382	407	1,605	1,629
Productive Area, Acres—Gas	3,805	3,805	551	551	3,746	3,746	1,350	1,502	3,682	3,715	599	599			1,090	1,090	1,624	1,624
STRUCTURAL FEATURES:																		
Avg. Water-Oil Content		5,910		5,904				6,012										
Avg. Gas-Oil Content		5,738		5,795				5,388										
Avg. Net Sand Thickness, Ft.		25.3		17.0		12.1		1.63		10.8		12.1		3.7		11.0		11.7
Orig. Ratio of Gas Cap. to Oil Sand, Volume	0.341	0.301	0.079	0.079	3.285	3.285	18.899	2.139	1.063	1.034		0.269			4,404	4.162	1.074	1.063
Type of Drive			Gas Cap. & Limited Water				Gas Cap. & Limited Water											
AVG. PHY. PROP. OF RES. ROCKS:																		
Porosity, Percent		24.0		24.3		24.4		24.4		24.4		24.4		24.4		24.4		24.4
Permeability, md		555		247		408		408		408		408		408		408		408
Avg. Interstitial Water Sat., Percent		22.5		26.6		30.4		29		29.9		30.5		31.7		31.3		31.5
AVG. ORIGINAL CHAR. OF RES. FLUID:																		
Oil Gravity, API at 60 °F		43.0		40.8		40.0		40.9		40.0		40.0		40.0		40.0		40.0
Sat. (Bubble Point) Press., psig		2,789		2,822		2,928		2,893		2,928		2,928		2,935		2,928		2,928
Form. Volume Factor		1.45		1.46		1.48		1.48		1.48		1.48		1.49		1.48		1.48
Viscosity, cp		0.3305		0.3246		0.3053		0.3117		0.3053		0.3053		0.2996		0.3053		0.3053
Dissolved GOR, cu. ft./bbl.		755		795		830		819		830		830		843		830		830
Avg Gas Content, gpm Propanes plus		1.26		1.76		1.30		1.79		1.30		1.30		1.31		1.30		1.30
PRESSURES & TEMPERATURES:																		
Orig. Res. Press., psig		2,789		2,822		2,928		2,893		2,928		2,928		2,935		2,928		2,928
At Subsea datum (feet) of		5,749		5,795		5,931		5,858		5,931		5,931		5,977		5,930		5,930
Current Res. Press, psig		2,138		1,643		2,451		2,395		2,439		2,404		2,241		2,521		2,363
Res. Temp. °F		179		180		183		182		183		183		184		183		183
DEVELOPMENT AND ALLOWABLE STATUS:																		
No. of Prod. Wells, Oil	179	199	34	34	16	16	2	8	40	41	17	17	1	1	1	1	19	19
No. of Prod. Wells, Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
No. of Penalized Oil Wells	50	57	5	5	6	6	1	1	22	22	10	10	0	0	0	0	6	6
No. of Inactive Wells	51	60	10	10	3	3	1	1	14	14	4	4	0	0	1	1	6	6
Top per Well Oil Allow., bbl./day	78	78	40	40	51	51	51	51	51	51	51	51	51	51	51	51	51	51
Daily Res. Oil Allow., Bbl.	10,768	11,993	1,166	1,166	593	593	68	374	1,428	1,428	557	557	54	54	73	73	698	698
STATISTICAL DATA: (7-1-57)																		
Cum Prod.:																		
Oil, Bbl.	44,063,542	48,737,663	5,405,276	5,405,276	2,172,443	2,172,443	103,093	465,197	5,109,837	5,295,390	2,057,133	2,097,133	172,493	172,493	216,941	216,941	2,515,179	2,515,179
Gas, Mcf—Oil Well	49,348,776	53,017,783	6,284,625	6,284,625	4,208,930	4,208,930	242,211	447,186	10,576,934	10,782,261	6,179,857	6,179,857	238,665	238,665	391,360	391,360	5,838,510	5,808,510
Gas Mcf.—Gas Well																		
Inj. Gas, Mcf.																		
Water, Bbl.	1,131,742	1,442,440	1,308,014	1,308,014	896,045	896,045		2,609	513,114	548,350	376,313	376,313			25,804	25,804	364,092	364,092
Avg. Daily Oil Prod., Bbl.	5,727	6,405	603	603	299	299	34	187	706	732	244	244	27	27	34	34	339	339
Avg Prod. GOR, cf/pb.	1,390	1,330	1,851	1,851	2,650	2,650	770	607	2,579	2,605	4,370	4,370	1,850	1,850	790	790	2,370	2,370

ervoir fluid parameters as a basis for oil unitization.

Gas plant facilities. The present Seeligson natural gasoline plant, which was built during 1947-48, and the gas gathering facilities and cycling lines throughout the field represent an investment of approximately $12 million which was made by the gas unit participants. The gasoline plant with a capacity of 70 Mmcf of low pressure gas daily, and 150 Mmcf of high-pressure gas daily, delivers its residue gas to Tennessee Gas Transmission line.

To initiate unit operation, a number of changes in the plant facilities will be necessary.

Unitization plans and formula. The most detailed and complex problems ever to confront a reservoir engineering committee were faced in the engineering evaluation of the Seeligson field for pressure maintenance. To the complex geologic and reservoir conditions already mentioned is added the fact that all of the 47 operators and all of the royalty owners should be agreeable to the unitization plans and their share of participation and returns. This was further complicated because not all productive acreage was to be included in the unit.

Also, it was only natural that there should be a considerable difference of opinion as to just what value should be assigned to various reservoir parameters, such as, net pay thickness for each and every zone, porosities, permabilities, fluid saturations, etc. These factors had to be worked out to the satisfaction not only of the individual operator and royalty owner concerned, but also to the other operators whose percentages would be affected.

Data processing. When the Seeligson engineering committee was first organized, it was necessary to collect, correlate and analyze engineering and geological data. Basic field and laboratory data had to be readily accessible by well, by groups of wells, and by reservoir segments. This necessitated double recording of many items. Intermediate processing steps were required to furnish basic data for reservoir calculations and also statistical and graphical histories.

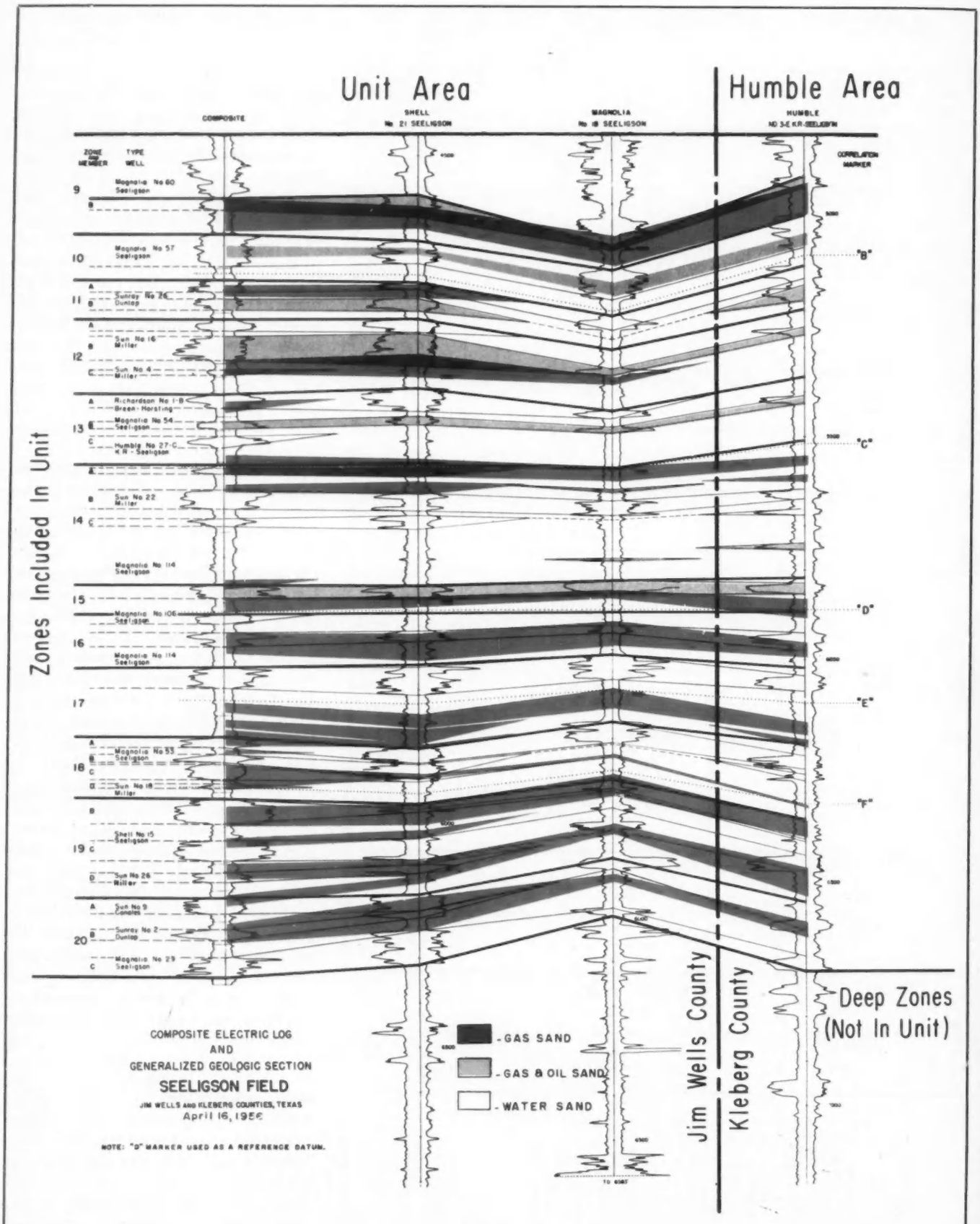


FIGURE 4—Composite electric log and generalized cross section of the Seeligson field. This drawing illustrates how the unitized portion of the field is cut-off at the Jim Wells-Kleberg County line and includes only those zones above Zone 20C4. The Humble area may cooperate on repressuring and the deep zones may be added to the unit at a later date.

TABLE 2—Results of Recovery Correlations

	RELATIVE WEIGHTS (Standardized)									
Log Permeability	1.0039	.9982	1.0342	1.0301	1.0508	1.0488	.6022	.9513	1.0313	.8320
Porosity	— .5756	— .5577	— .5938	— .5756	— .6200	— .5839	.....	— .5445	— .6781	— .4751
Log Viscosity	— .5443	— .5415	— .5611	— .5574	— .4859	— .5462	— .4471	— .5510	— .5716	.....
Thickness	— .2032	— .1847	— .2119	— .1901	— .1919	— .1996	— .3686	— .2652	.....	.....
Interstitial Water	.1402	.1390	.1440	.1436	.1604	.1670	.0810	.....	.....	.....
Depth	.2790	.2519	.2119	.1789	.0941	.....	.....	.....	.....	.....
Formation Volume Factor	— .2478	— .2326	— .1970	— .1763	.....	.....	.....	.....	.....	.....
Area	.0786	.0814	.....	.....	.....	.....	.....	.....	.....	.....
Well Spacing	— .0474	.....	— .0534	.....	.....	0.0000	.....	.....	.....	.....
Multiple Correlation Coefficient	.8782	.8777	.8759	.8753	.8721	.8694	.7799	.8586	.8205	.6046

This table is the result of the mathematical approach to the determination of the effect the various parameters have on reservoir performance and ultimate recovery as well as the way that they affect the weight of the other parameters. Log permeability was determined to be the best prediction of recovery with a correlation coefficient of .4999. By considering porosity as well, this can be increased to 0.6046. Five parameters give the optimum coefficient of 0.8694.

working, the every increasing workload, and the difficulty in finding competent personnel caused the committee to adopt a punch card system of data processing. This system eliminated the need for duplicate records. Correction and recorrelation of basic data were made simple and the data were filed where the simplest and smallest segments are available to be combined in any fashion desired.

Coordinate system in master well cards. Well numbers usually are assigned at random throughout a lease, and leases and operating companies are distributed throughout the field in an irregular pattern. To select data pertaining to a specific geographic location, it was necessary to assign coordinate numbers to each well. A deck of master cards was punched with company, lease, well, and coordinate fields.

A sorting machine operator could select a card for each well within any coordinate boundary. The selected master well cards could then be used with the collator to pull from the file any data desired.

If the data were listed in a coordinate sequence when prepared for study or contouring, drafting room time could be reduced by almost 50 percent.

Complex boundaries requiring many sorting operations had the coordinate boundaries recorded on a mimeographed form, punched and verified onto cards. Master well cards could be selected to comply with as many as three pairs of horizontal limits and an unlimited number of vertical limits.

Elevation, total depth, deepest zone penetrated, perforation depth, casing size, and other significant well data also were punched into the master cards.

Controlled merging of various files. Drill stem test and core analyses data were merged with data interpreted from electric logs reflecting revised geologic correlations.

Analyses data for approximately 13,000 care samples and 11,000 reports on the results of drill stem testing as well as multiple records of many tests were in the file. Approximately 11,000 sands were identified, correlated and recorded from 750 logs.

Core analyses and drill stem test data were selected in depth groups according to the new correlations and irrespective of the zone designations which had been originally assigned them during field development.

Sand volumes by grid method. A method was developed by the Seeligson comittee, under R. K. Guthrie, whereby a transparent grid of numbered rectangles is superimposed upon an isopach map and sand thicknesses are determined and recorded within each rectangle.

Cards are punched and verified from a paper print made from the transparent grid and machine-processed to obtain sand volumes. Sand volumes may be machine-compiled from the cards by lease, reservoir or any reservoir segment for which sand volumes may be required.

Multiple correlation analysis. In a unitization effort, a completely unbiased method of correlating the many variables effecting reservoir performance and ultimate recovery is necessary. A mathematical approach using the "Method of Least Squares" was used with the calculations being carried out on an electronic computer. The object is to determine which of the many parameters had significant effects upon secondary recovery efficiency, and to derive an equation for the prediction of recovery from them.

A matrix of correlation coefficients was obtained by correlating each known quantity considered in the equation with each of the others. A matrix of intercorrelations was developed as in Table 2. The five most important parameters gave a total coefficient of .8694. Addition of the remaining four parameters increased this coefficient by only .0088. Therefore, only five factors—log permeability, porosity, log viscosity, sand thickness, and interstitial water—were used in the final equation. Table 2 shows the relative weight of each parameter in relation to all other parameters considered, and the way in which each is affected when other parameters are dropped from the equation.

The actual saving in engineers' time is impossible to estimate, and it increases as experience is gained with the machines.

As a result of these efforts in mechanizing the petroleum engineering data-processing procedure, it has been proved that the application of punch card methods is a considerable advantage where there is a sufficient concentration of petroleum engineering computation and their associated data-processing problems.

Explanation of unit formulae. The Seeligson field Operators Committee formed the Oil and Gas Consolidation Subcommittee, in February, 1952, to determine the basis for evaluating the gas unit and oil unit so that these could be merged into one unit. This included the development of proper factors for use in equating oil and gas equities in the proposed unitization formula, namely:

1. Estimate the reasonable value of

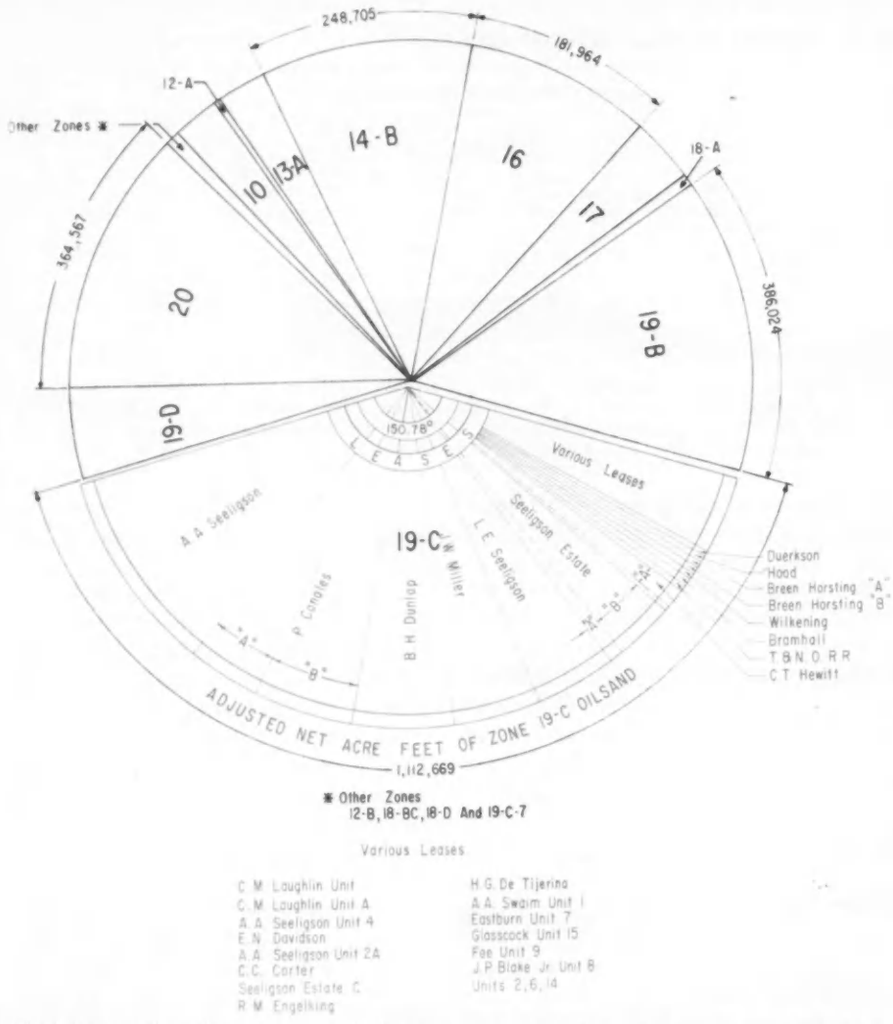


FIGURE 5—Size of black wedges indicate the relative oil production of a zone to the total unit oil production for the period July 1, 1954 to January 1, 1955. In the formula these are the production factors (A). As an example: Zone 19-C produced 1,112,669 barrels of oil or 41.883 percent of the total production during this period. 41.883 percent of a complete circle is 150.78°. This 150.78° wedge of Zone 19-C is then divided between the operator's tracts on a net acre-feet basis, as shown in color.

the oil reserves through the base of zone 20-C4.

2. Estimate the reasonable value of the free gas reserves through the base of zone 20-C4.

3. Combine the values of the oil reserves and the free gas reserves with the proposed oil unit participation factor and a recomputed gas unit participation factor to determine each operator's interest in the combined oil and gas unit.

TABLE 3
Production Data and Zone Production Factors (A) for Proposed Oil Unit, Seeligson Field Period July Through December, 1954

ZONE	Prod. Bbls.	Fraction
10	56,366	.021217465280
12A	7,476	.002814139205
12B	.....	.....
13A	84,068	.031645138401
13B	.....	.....
13C	.....	.....
14B	248,705	.093618310726
14C	10,600	.003990085015
16	181,964	.068495455632
17	55,625	.020938538752
18A	16,125	.006069922724
18BC	4,208	.001583988466
18D	2,976	.001120235199
19B	386,024	.145308356405
19C	1,112,669	.418834330541
19C7	426	.000160356247
19D	124,792	.046974593322
20	364,561	.137229187095
	2,656,585	1.000000000000

The oil production factor (A) was determined by dividing the oil production from each zone for the last half of 1954 by the total oil production for zones 20C4 and above for the same period.

Here a note of explanation is in order: The unit does not include the entire field, nor do all reservoirs lie wholly within the unit. Note Table 1 and Figures 1 and 4. The western productive limits are defined by the major fault, while the eastern edge of the unit is defined by the Jim Wells-Kleberg County line.

Only zones above 20-C4 are presently within the unit, and of these only 18 zones will be repressured or cycled.

The unit consists of 42 tracts, each tract numbered as in Figure 1. The unitization formulae had to resolve the oil and gas bearing zones beneath each tract into a tract participation formula.

The method and procedure was as follows:

A. Oil Unit Participation Factor

1. The value of an oil zone in relation to all zones in the proposed unit area was equated by production statistics. Each zone was assigned a production factor (A) represented by the unit zone percentage of the total unit oil production from zone 20-C4 and above during the last half of 1954. See Figure 5 and Table 3.

The initial oil reserves in a given zone under a lease have been introduced into the unitization formula by dividing the participation in the zone on an adjusted net acre-feet basis. To give credit for structural position, the volume of net oil sand overlain by gas, and 10 feet or less in thickness, was discounted 50 percent. The determination of adjusted net acre-feet of oil sand is illustrated by Figure 6.

2. The participation of each tract in each zone (C) was determined by the ratio of the tract adjusted net acre-feet in each zone to the unit zone total adjusted net acre-feet of original oil sand (B), multiplied by the zone production factor (A).

The summation of the individual tract participation in all zones represents the tract participation in the oil and solution gas (D).

3. The value of each tract in the oil unit was also expressed in terms of the production performance of the tract or lease as follows:

$$E = \frac{\text{(Tract Oil Production from Zones 20-C4 and above for last half 1954)}}{\text{(Unit Oil Production from Zones 20-C4 and above for last half 1954)}}$$

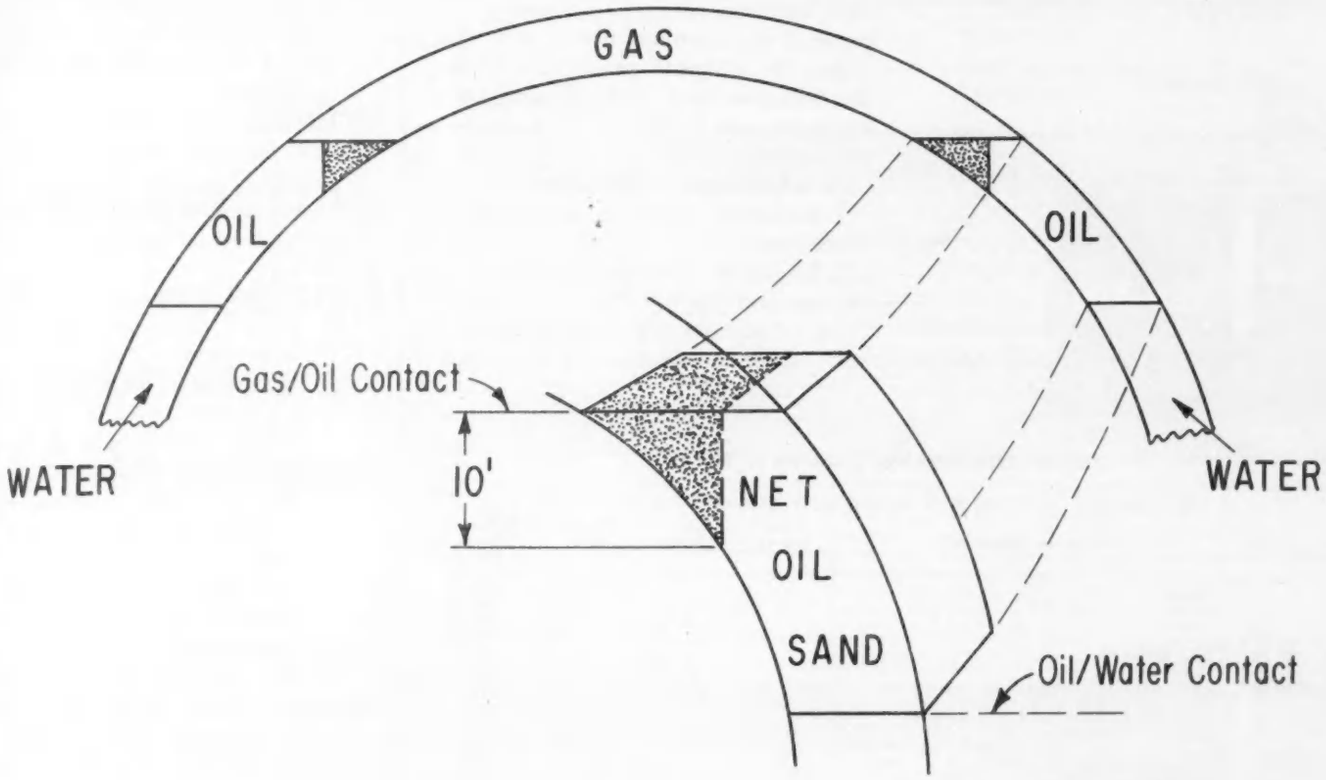
4. To determine the final oil unit participation factor (F) for a tract:

$$F = \tfrac{2}{3}\,D + \tfrac{1}{3}\,E$$

B. Gas Unit Participation Factor

1. Using approved, recent, geological maps of the Seeligson field, the participation of each operator in the Seeligson gas unit was recalculated. The participation of each tract in the gas unit was based on the following 3 factors:

(a) **Initial free gas in place (G)** under each tract, divided by the total initial free gas in



Total Volume Of Net Oil Sand = 1000 Ac. Ft.

Volume Of Net Oil Sand Overlain By Gas And 10 Feet Or Less In Thickness = 100 Ac. Ft.

Adjusted Volume Of Net Oil Sand = $1000 - \frac{100}{2}$ = 950 Ac. Ft.

FIGURE 6—The initial oil reserves in a zone were included in the formula by dividing the participation in each zone on an adjusted net acre-feet basis. So that structural position would be taken into account, the net oil sand overlain by gas, and 10 feet or less in thickness, was discounted 50 percent.

TABLE 4

I. INTERESTS SIGNED, COMPARED IN TERMS OF PARTICIPATION AND QUALIFICATION UNDER SEELIGSON FIELD UNIT

(a) Interests signed in all tracts within entire unit area.

W. I.	R. I.
97.97%	85.31%

(b) Interests signed in "Qualified" Tracts only, compared to entire unit area.

W. I.	R. I.
97.01%	78.24%

II. COMPARISONS OF INTERESTS SIGNED, EXPRESSED IN TERMS OF SURFACE ACRES

(a) Within outer limits of entire unit area, embracing 14,238.56 acres.
(1) W. I. Signed: 13,893.94 Ac. 97.58%
(2) R. I. Signed: 12,388.34 Ac. 87.01%

(b) Tracts in which all or part of Working Interest is signed: 13,979 Ac.
(1) W. I. Signed: 13,893.94 Ac. 99.39%
(2) R. I Signed: 12,276.44 Ac. 87.82%

(c) Signatures obained in qualified tracts, comprising 13,817.61 acres.
(1) W. I. Signed: 13,817.59 Ac. 100.00%
(2) R. I. Signed: 12,135.80 Ac. 87.82%

place under the proposed unit.

(b) **Liquid gas products (H)** originally in place under each tract, divided by the total liquid gas products in the proposed unit area.

(c) **Residue gas (I)** available from each tract, divided by the total volume of residue gas within the participating area.

2. The gas unit participation factor

TABLE 5—Schedule of Principle Operator's Percentages of Participation

Dunlap Oil Corporation	2.211795
Magnolia Petroleum Company	14.950228
W. A. Richardson et al	1.475887
Shell Oil Company	11.416951
Sinclair Oil and Gas Company	7.944166
Sun Oil Company	30.664661
Sunray Mid-Continent Oil Company	25.136116
The Texas Company	.074230
Texas Gulf Producing Company	2.690451
Others	3.435515
	100.000000

(J) for any tract is 1/3 the sum of the above factors;

$$\left(J = \frac{G + H + I}{3}\right)$$

C. Combined Unit Participation

1. The value of the oil reserves and the value of the free gas reserves, gas products, and residue gas for each tract was combined on a relative dollar value basis. The relative value of the oil and gas units was originally calculated as of Feb. 1, 1953, and were recalculated as of Jan. 1, 1955.

2. To calculate the participation of a lease in the combined unit, assume:

K = Total Value of Oil Unit as of Jan. 1, 1955

L = Total Value of Gas Unit as of Jan. 1, 1955

Then:

M = K + L = Total Value of Consolidated Unit.

In summation the participation formula is:

$F = \frac{2}{3} D + \frac{1}{3} E$ Tract Oil Unit Participation

$J = \frac{G + H + I}{3}$ Tract Gas Unit Participation

$M = K + L$ Total Value of Unit

Combined participation (P) in oil and gas unit for a tract:

$$P = \frac{K}{M} F + \frac{L}{M} J$$

Plan For Pressure Maintenance. Comprehensive reservoir and geologic studies indicated that unitized pressure maintenance was necessary to prevent underground waste and increase the ultimate production from the Seeligson field. The following advantages both to the operator and to the royalty owner are cited:

A. Advantages to operators

1. Reduced operating and investment costs.

2. Increased ultimate recovery of oil, gas and gas liquids.

(a) Maximum utilization of the energy contained in the large gas caps.

(b) Prevention of underground waste through up dip migration of oil into gas saturated sand zones.

(c) The ultimate production of oil will be increased approximately 60 million barrels.

(d) More efficient recovery processes under unit operation; such as,

(1) Water injection to supplement deficient natural water drives.

(2) Revision of oil withdrawal patterns through revised MER and proration formulae and allowable transfer programs, resulting in a more uniform encroachment of gas and water, and the reduction of bypassing and coning to a minimum.

3. Ultimate income from gas and oil production will be increased by approximately 40 percent. The ultimate income will be obtained within a shorter period of time.

B. Advantages to royalty owners

1. Increased ultimate income.

2. Royalties will be returned at a more rapid rate under unitized operation than under competitive operation. This accelerated return of royalties increases the present value of the royalty interests.

3. Uniform operation of all properties throughout the proposed unit area by the unit operator.

TABLE 6—Injection Rates (Tabulate W/Plat 1)

Reservoir	Well or Location	Gas Input	Gas Cycling	Water Input	Daily Rates Bbls. or Mcf.
10	Magnolia Seeligson 125	X			7,300
	Magnolia Seeligson 94		X		2,200
	Sunray-Dunlap 37		X		3,400
13A-02	Sun-Miller 22			X	1,200
13A-05	Seeligson Gas Unit 2	X			6,000
	Magnolia Seeligson 67		X		3,000
	Magnolia Seelgison 156		X		5,000
	Magnolia Seeligson 183		X		3,000
14B	Magnolia Seeligson Unit 2A-2	X			4,500
	Magnolia Seeligson 72			X	1,000
	Sun Canales 56			X	1,000
	Vicinity of 1000's of Sunray Seeligson "C" 1			X	1,000
16D	Magnolia Seeligson 29	X			3,600
	Sunray-Hewitt 2	X			2,800
	Magnolia Seeligson 33		X		1,500
	Magnolia Seeligson 45		X		534
	Magnolia Seeligson 58		X		1,500
	Seeligson Gas Unit 4			X	500
	Sunray Seeligson C No. 3			X	900
	Vicinity of Sun Canales 57			X	900
17-02	Magnolia Davidson Unit 2	X			11,000
	Seeligson Gas Unit 19		X		7,000
17-05	Seeligson Gas Unit 23	X			10,000
	Magnolia Seeligson 99		X		5,000
18A-05	Seeligson Gas Unit 20	X			10,000
	Magnolia Seeligson 168		X		5,000
19B 03	Magnolia Seeligson Unit 4 No. 5	X			21,200
	Magnoiia Seeligson Unit 44		X		5,000
19B-03	Magnolia Seeligson 69		X		1,230
	Sunray Dunlap 6		X		450
	Sun Miller 20		X		14,000
	Vicinity of Sun Canales 104			X	1,800
	Vicinity of Sun Canales 52			X	1,000
	Vicinity 1000's of Sun-Canales 57			X	1,400
19C-04	Sunray-Seeligson "B"-9	X			5,200
	Magnolia Seeligson 72			X	2,500
	Sunray Seeligson 28			X	1,000
	Seeligson Gas Unit 4			X	1,900
	Vicinity of S. Canales 108			X	1,500
19D-01	Seeligson Gas Unit 5			X	700
20A-03	Sun-Canales 60	X			6,700
	Sunray Seeligson "B" 4		X		4,500
	Magnolia Seeligson 97		X		1,500
	Vicinity of Sunray Dunlap 59			X	900
20A-05	Seeligson Gas Unit 20	X			17,000
	Magnolia Seeligson 9		X		1,500
	Magnolia Seeligson 58		X		3,500
	Magnolia Seeligson 139		X		5,000
	Seeligson Gas Unit 17		X		7,000
20B-03	Sun-Miller 29	X			1,500
	Sun-Canales 59	X			760
	Magnolia Seeligson Unit 4 No. 2		X		300
	Sunray Seeligson "B" 12		X		700
	Vicinity of Sunray-Wilkening Unit 1			X	900
	Vicinity of Sun-Canales 95			X	1,000
20C-02	Sunray-Seeligson "B" 3	X			1,150
	Vicinity of Sun-Canales 7			X	410
20C-13	Vicinity of Sun-Canales 7			X	150
20C-15	No initial injection contemplates	X	X		?
20C-44	Seeligson Gas Unit 2	X			20,000
	Seeligson Gas Unit 21		X		9,000
	Seeligson Gas Unit 22		X		11,000
	Vicinity of Sun-Canales No. 7			X	600

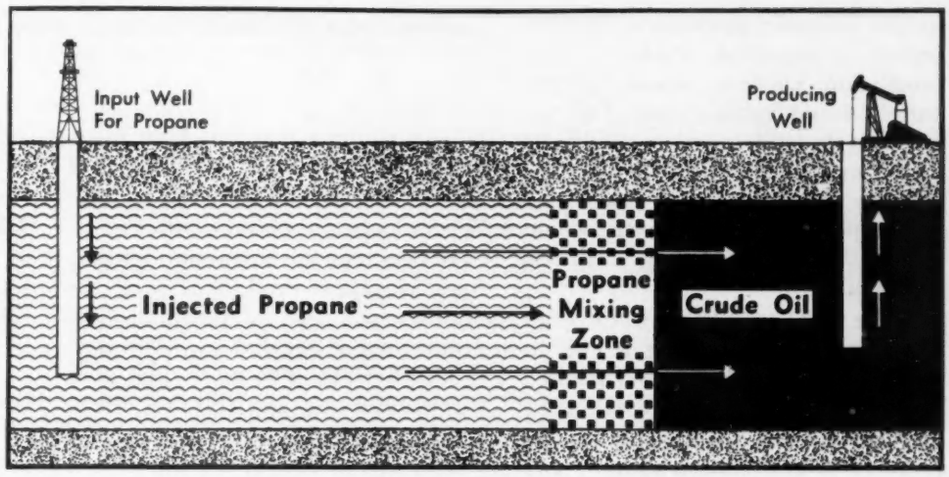
Signed interests. With the engineering studies completed and the unitization formula derived it was still necessary to sell this agreement not only to all of the operators, but to the royalty interests as well. The high percentage of acceptance signatures denotes a fair and impartial job that was well done. The working interest and royalty interest comparison of percentages signed is shown in Table 4.

With Sun Oil Company, the largest participating interest (Table 5) as operator, water input was inaugurated on a limited scale on March 1, 1958. The Seeligson Gas Unit 5 will be used as the first input well. This well is located in Tract 36 and the new designation of the well is No. 36-1. The tract will be used to identify the location of the well.

The well will be equipped with

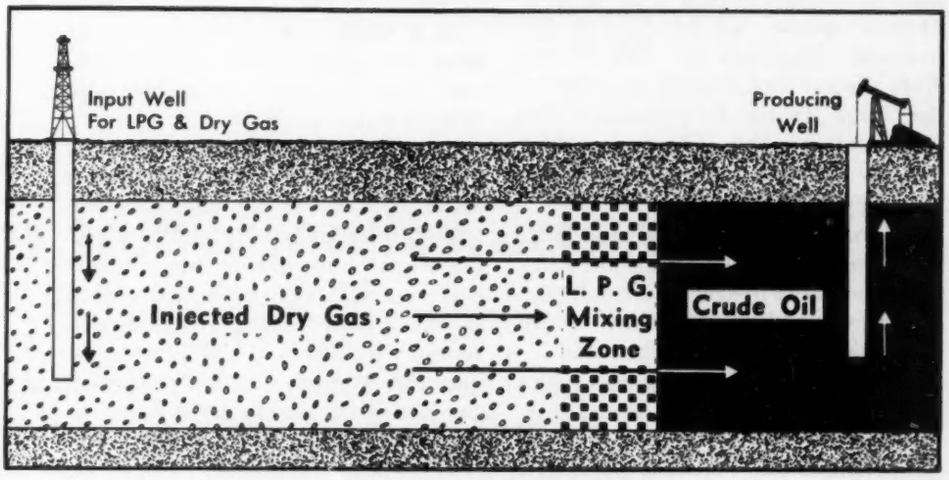
Continued on Page 202

New repressuring method promises to triple output



Sunray's Double-Purpose Project at Newhall

Miscible-phase displacement method used in California and New Mexico is expected to increase recovery by approximately 300 percent



Bisti Field LPG Injection Project

By Charles Schnake
Sunray Mid-Continent Oil Company, Tulsa

Two PROJECTS which reservoir engineers hope will triple crude oil recovery from oil pools in California and New Mexico have been initiated by Sunray Mid-Continent Oil Co. The two projects are:

1. A combination LPG (liquefied petroleum gas) storage and LPG pressure maintenance program in the Newhall-Potrero field in southern California.

2. An LPG injection system in the Bisti field of New Mexico.

A new type of secondary recovery method known as miscible-phase displacement is being used in each system. This system employs a liquefied petroleum gas which will mix with the crude oil.

Newhall-Potrero Project. The program is designed to use the propane-injection system to maintain reservoir pressure and to increase oil recovery. At the same time, the Newhall-Potrero field just north of Los Angeles will be used to store the liquefied gas underground during the summer months when the propane market is below normal.

This is the first time this double-purpose operation has been attempted. Increased recovery is assured. Only time will tell whether the LPG underground storage project will be economical. The storage plan had been under consideration by the California engineering staff for several years before the small reservoir was tapped.

The California project was started last summer with propane being injected through one injection well at a rate of 400 barrels a day. One producing well is flowing about 200 barrels of oil a day under the LPG pressure maintenance. The pool, in the Upper Miocene formation, was discovered in August, 1956, when an idle lower-sand well was recompleted. After a second well was recompleted, flow pressures decreased rapidly. After 25,000 barrels of oil had been produced, the producing wells were shut in, awaiting installation of necessary equipment to start the new recovery plan. The pool has an estimated 1,000,000 barrels in place.

The propane used in the project is produced at the Newhall gas products plant located in the center of the field. Demand for propane sales in the Los Angeles area fluctuates between winter and summer months. Previously, part of the propane produced during the summer months was injected in low concentrations with dry gas into other lower zones as part of the Company's field pressure maintenance program.

Out of the 1 million barrels of crude

in the reservoir, recovery of 650,000 barrels is expected. Under normal production methods, about 250,000 barrels would be recovered. Dry gas injection is used in other producing formations in the field to increase recovery. If that method were used in this pool, ultimate recovery would be 320,000 barrels of oil, engineers estimate.

If the LPG storage project doesn't prove economical, nothing is lost. In that case, the LPG injection method of secondary recovery will continue by leaving the slug of propane in the formation and driving it with dry gas.

Bisti Project. The other new program involves the Bisti field of New Mexico, where Sunray is a major producer. Injection of LPG in the Bisti project was started in September, 1957, in the first phase of the long-range project. There are 100,000,000 barrels of oil in place in the Bisti-Lower Gallup pool.

Approval was received in July, 1957, from the New Mexico Oil Conservation Commission to install the first miscible-phase secondary recovery project ever used in the state.

While Sunray is operator of the pilot program, two other firms, British-American Oil Producing Company and Phillips Petroleum Company are partners in the program. Supporting the project are Shell Oil Company, Amerada Petroleum Corporation and El Paso Natural Gas Company.

A combination LPG injection and dry-gas injection is being used. The LPG slug is being injected into the formation through an input well and will be followed by dry-gas injection. The input well is centrally located between the four wells involved in the pilot project. The pilot program embraces 160 acres in San Juan County, combining wells on four 40-acre tracts for operation under a cooperative agreement.

Sunray's plans are to inject a total of 33,000 barrels of LPG, then follow up with a dry-gas injection at the rate of 1 million cubic feet a day and an estimated 50 percent increase in oil recovery is expected in the operation as opposed to a 25 percent recovery by primary operations.

ACKNOWLEDGMENT

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Seeligson Unit Formed for Secondary Recovery

Continued from Page 200

2½-inch tubing that has been internally coated with plastic. A string of gas lift valves will be used so that the well can be backwashed.

Water will be obtained initially from a supply well drilled in the southwestern part of the field. The water sand is located at 3,500 feet. A closed water system is used with the water being run through scrubbers, a surge tank to settle sand and debris, a filter and then pumped into Well No. 36-1 in Zone 19D-01 with a engine-driven, horizontal triplex pump.

At a later date produced water from the various tracts will be gathered, run through the system and used as input water.

With the old Gas Unit absorbed by the new Gas and Oil Unit, a number of changes in the gas input and gas cycling operations were made. Forty-three gas input, gas cycling, and gas make-up wells were reworked. A new 1,000-psi intermediate gas gathering system was installed. The present gas injection system and high pressure gas gathering system have been expanded. More than $1 million worth of work has been done on the gas phase of the unit.

Development plans call for additional wells to be converted to either water or gas input or to gas cycling. These wells and the reservoir that they will service are indicated on Figure 1. The anticipated input or cycling rates for these wells are presented in Table 6.

Injection of residue gas into the gas caps of the major oil zones will allow the unit operator to increase the present oil producing rates of these zones. Injected gas will be credited against the produced casinghead gas from high gas-oil ratio wells, allowing the unit to increase the oil producing rates of such wells. Such a plan of operation has been termed a net gas-oil ratio program.

This plan will also permit efficient control of the movement of oil up and down dip in all reservoir segments and prevent underground waste by migration into gas saturated sands. Reservoir pressures will be maintained to minimize excessive release of gas from solution and will result in more favorable fluid properties for efficient recovery.

In addition to the above programs, a plan has been adopted to accelerate the exploitation of other unitized gas and oil zones in the field. This will enable the operators to realize an immediate and efficient recovery of gas liquids from the gas caps and oil from the thin oil columns of the Seeligson field.

Water injection into the down dip flanks of some of the major oil zones is anticipated for the future. The details of such water injection programs will be determined after extensive engineering studies involving the further use of potentiometric models and Sun's electronic analyzer as aids in determining the most efficient method of depleting each zone.

Detailed engineering studies will be continued after unitization in an effort to efficiently deplete all of the oil and gas reserves in the Seeligson unit.

As deeper zones in the field are developed and defined they can be brought into the existing unit.

ACKNOWLEDGMENT

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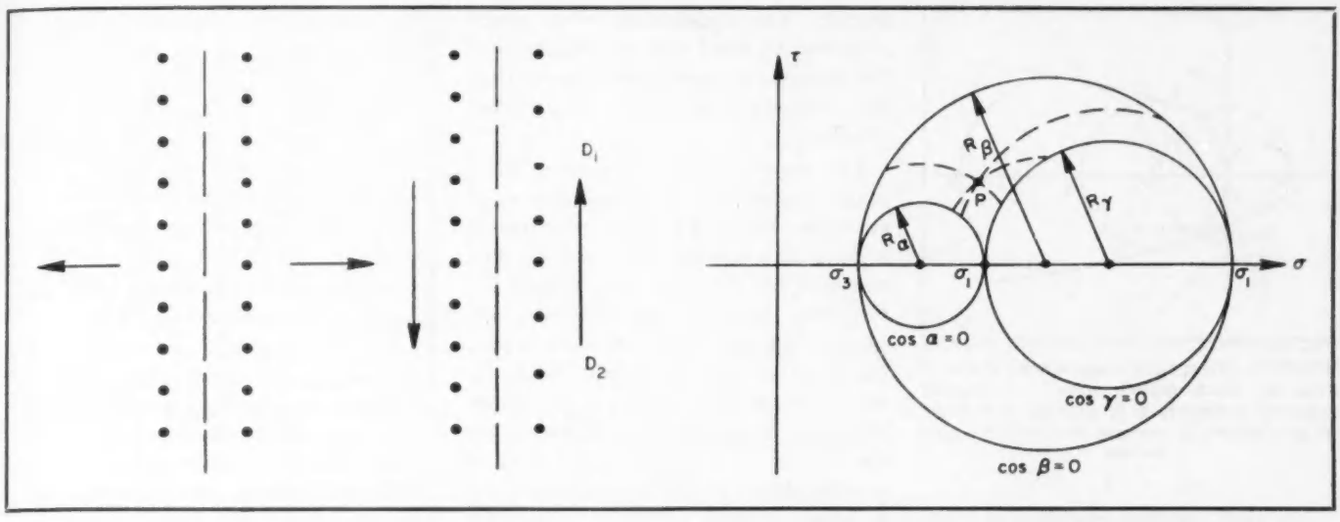

FIGURE 1—Cleavage fracture. "Slip" fracture.

FIGURE 2—Representation of three-dimensional state of stress by circles according to Mohr.

What happens to hydraulic fractures?

A better understanding of the forces which govern fractures should help the engineer and producer apply fracturing techniques more effectively. This note concerning the mechanism of artificial and natural hydraulic fracture systems will improve that understanding.

By H. Ode
Shell Development Company
Houston

IN THE LAST two decades the interest of the oil industry in phenomena connected with fluid-induced pressures to fracture rocks has grown tremendously. Since the development of various fracture procedures aimed at stimulating production by fracturing the formation by means of hydraulic pressure, the question of what happens and why it happens has assumed considerable importance. In the original hydraulic fracturing process a hydrocarbon gel acting as a vehicle for a "propping agent" (sand) to hold fractures open is forced into the reservoir rock. The gel is then broken by a breaker solution. Most of the procedures developed since then differ only in minor details from this basic technique. There are two opposed schools of thought concerning the geometrical pattern of the induced fractures in the rock. According to one, the fractures are horizontal and the results of the disappearance of a large quantity of fluid into the formation is to lift the overburden.

The other school holds that the fractures are largely vertical. The argument is that the pressure at which the fluid disappears into the formation is in many cases lower than the overburden pressure. Measurements of pressure which show this were made in the study of three phenomena known before the advent of the various fracture techniques: pressure breakthrough, lost circulation and squeeze-cementing.

Pressure breakthrough is a phenomenon occurring during secondary recovery operations. Water is initially taken at a rate which is about linear with pressure. At some critical pressure this rate suddenly jumps discontinuously with pressure. The critical pressure is about 0.5-1.7 times the overburden pressure.

One speaks of lost circulation when mud pumped into the well is not returned, even though no cavities are present in the formation. This is concluded because a lightweight mud may be returned and a heavy one not. Mud never obtains the bulk density of the rock through which the well has been drilled, and hence the pressure at which the formation cracks must be less than the overburden pressure.

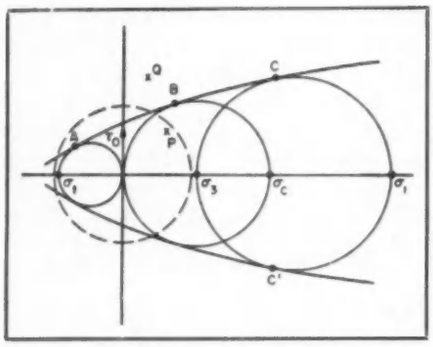

FIGURE 3—Stress circles representing states of stress at which rupture occurs. For loosely cemented sediments it is possible that circle for pure shear (ξ) contains the circle for pure tension.

The only tangible evidence of fracture caused in a well by fluid pressure is furnished by cores obtained from a squeeze-cementing operation. A photograph of such a cement-filled crack in a core obtained from a sidetracked and redrilled hole is shown in a figure accompanying a paper by Howard and Fast (1950).

It is the object of this article to discuss the orientation of the cracks in the formation due to hydraulic pressure and to point out that what happens around a well bore may be duplicated on a much larger scale around volcanic plugs.

Essentially there seem to be two ways in which a separation into two or more parts of a material can be achieved (Figure 1):

1. By cleavage.
2. By shear.

The first mode of rupture one might call brittle rupture. One important characteristic of this mode of rupture is that it proceeds very rapidly and once started cannot be stopped at will. The second mode of rupture resembles more ductile fracture, and its mechanism is postulated to be a motion of small imperfections in the material. Characteristic of the ideal case is that this mode of rupture can be halted at any moment by an appropriate change of the applied load. The ideal case of shear fracture is provided by a single metal crystal of proper orientation deformed at sufficiently high temperature. Owing to the movement of the imperfections in the crystal lattice D_1 and D_2 (Figure 1) (dislocation), the crystal shears apart on a slip plane. The abruptness at which the fracture process occurs in wells is an indication that we are dealing largely with a process which is more brittle than ductile. The suddenness with which a too-heavy mud may disappear into the formation especially suggests that the formation of cracks is a rapid process.

Let now a few well-known facts about the graphical representation of stress be stated. The state of stress at a point in a stressed body can be represented by three circles (Figure 2). On one axis of the diagram are plotted the principal normal stresses, on the other axis the shears. Then the stress acting on a plane of any orientation α, β, γ, where α, β, and γ are the directional cosines of the normal to the plane, is given graphically by a point of the diagram inside the largest and outside the two smaller circles. Figure 2 becomes especially significant for the interpretation of experimental data if two principal stresses are equal. Then one circle of Figure 2 becomes a point, and the two others become coincident. Such a state of stress obtains in so-called triaxial loading tests. The procedure in such a test is to subject a small cylinder of rock to hydrostatic pressure and to superpose a (positive or negative) axial force on the specimen by means of a suitable arrangement of the press. In this manner the state of stress, which is assumed to be homogeneous throughout the specimen, can be measured at the moment of fracture. By determining this state of stress at fracture under various conditions of loading and by collecting all corresponding stress circles in a single diagram, one sees that those circles allow an envelope (Figure 3). A point P within the envelope represents a state of stress which does not lead to fracture, a point Q outside it, a state of stress which does. The form of this envelope is supposed to be a property of the material. For most substances it has the tendency to become flatter with increasing confining pressure so that it resembles a parabola. It is evident that this envelope should be tangent to the limiting stress circles for tension, compression and pure shear. Topping (1955) recently pointed out that for some rocks this is not the case. The circle for pure shear completely encloses the limiting circle for tension. The points in which the stress circles are tangent to the envelope, C and C', determine in space the position of two planes (or rather cones) on which the stresses are σ_N, τ_S and σ_N, $-\tau_S$. According to

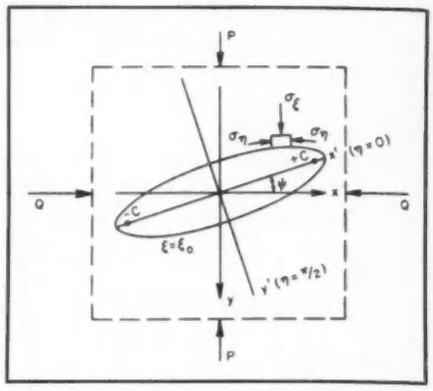

FIGURE 4—Coordinate systems used for elliptical crack.

Mohr, to whom we owe the best known theory of strength, the planes will be the planes of rupture. He assumed that the intermediate principal stress was immaterial to the fracture. The latter assumption does not appear to be valid for very high mean pressures. The attractiveness of Mohr's hypothesis is that it relates in a very simple manner the fracture pattern with the stress field within the solid. It leads, moreover, in some cases to rather surprisingly good predictions of orientation of fault planes.

At high mean pressures the rupture which takes place in the rock is no longer completely brittle. In fact the occurrence of rupture depends very much on the magnitude of the shear stress τ_S along the plane of rupture. The deformation of some sedimentary rocks during triaxial tests results sometimes in stress-strain curves in which no indication for fracture can be found even though the specimen upon removal from the press-assembly shows a clear fault. Both parts still hang firmly together and cannot be taken apart by hand. One could therefore suppose that the flatter part of Mohr's envelope is an envelope to states of stress during ductile rather than brittle failure.

How then can we explain the fracture around the well bore? Let us imagine that first a small crack of some unknown orientation forms. Now at the sharp edge of the crack a stress concentration is created which only necessitates a slight pressure for further propagation. In a fluid-saturated rock, a slight pressure differential with respect to the pore fluid pressure is required. The initial formation of such a crack need not concern us. It is likely that cracks of many different orientations are present everywhere along the hole and

we need only to investigate which of them are likely to propagate further.

The analysis of the stresses in the neighborhood of a crack was used 35 years ago by Griffith (1920) as the basis of his ingenious hypothesis of brittle rupture. Griffith was led to his hypothesis by the discrepancy between observed values in strength and those to be expected theoretically. The former were 10-1000 times smaller than the computed ones (Orowan, 1949). To account for this he supposed that the material, instead of being perfectly homogeneous, was full of random cracks of elliptical shape. One such crack is shown in Figure 4—oriented at an angle ψ with one of the principal stresses. The crack is assumed to be an ellipse of very high eccentricity. If a material containing one such a crack is subjected to a load, stress concentration of considerable magnitude are caused at the tips of the crack, and therefore the stresses causing rupture are in fact quite a bit higher than one infers from the applied load. The condition that the crack spreads is then as follows: Imagine a plate containing at its center one elliptical crack loaded along its edge by a constant system of stresses. Suppose that we give the crack a small virtual extension *dl*, then some energy proportional to *dl* is needed to break the bonds over the length *dl*. Computations show that the strain energy of the plate connected with this virtual increase in length of the crack increases. Far from the crack very small displacements take place and consequently the applied forces do a certain amount of work. When now the work done by the applied forces is smaller than the sum of the increases in surface energy and the strain energy of the plate, nothing will happen. In other words in these circumstances the crack is stable. However, when this sum is smaller than the work done by the applied forces, the crack is in unstable equilibrium with the applied forces and will spread rapidly.

The necessary stress analysis is most conveniently carried out in elliptical coordinates ξ, η, but need not be repeated here. Figure 5 shows graphically the behavior of the normal stress component tangential to the crack and close to it, for the case where the crack is oriented at 45 degrees to the direction of universal compression. It is found that high tensile stress occurs close to the tops of the crack. These stresses increase with the eccentricity of the crack. By considering cracks of various orientation, we can, for any given applied stress field, find the orientation of the crack having the largest tensile stress on its boundary. Further analysis will show that the envelope which can be expected for the limiting stress circles is an exact parabola. This parabola is shown in Figure 6. It is to be noted that Griffith makes the assumption that until the moment of fracture, Hooke's Law remains exactly valid. That is to say, no account is taken of energy which might be dissipated in plastic deformation near the crack. This assumption makes Griffith's hypothesis less suitable as an explanation of the parabolic shape of the envelope since, as was mentioned before, in the range of higher stresses rupture is undoubtedly accompanied by considerable plastic deformation. However, if the crack is propagated by internal pressure in the crack, it is likely that little permanent deformation occurs and

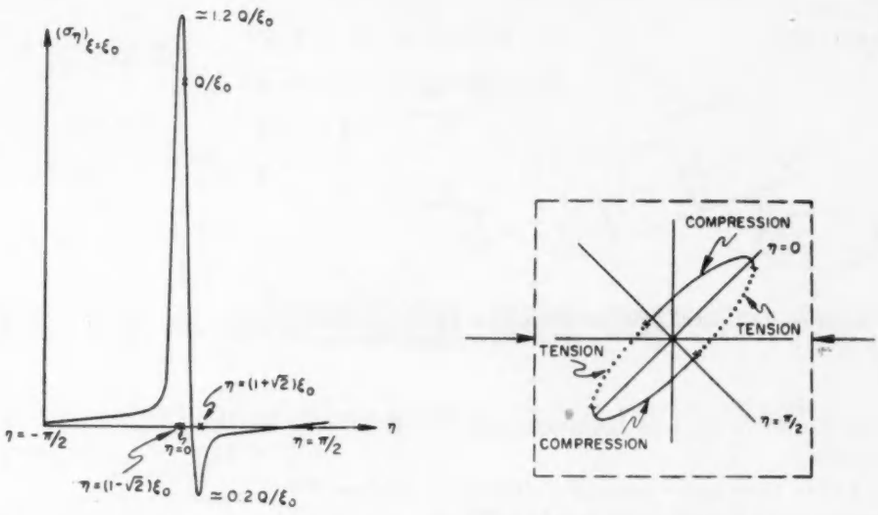

FIGURE 5—(Left) Magnitude of $(\sigma_\eta)_{\xi=\xi_0}$ around a crack inclined at 45 degrees with respect to compression. (Right) Distribution of compression and tension around same crack.

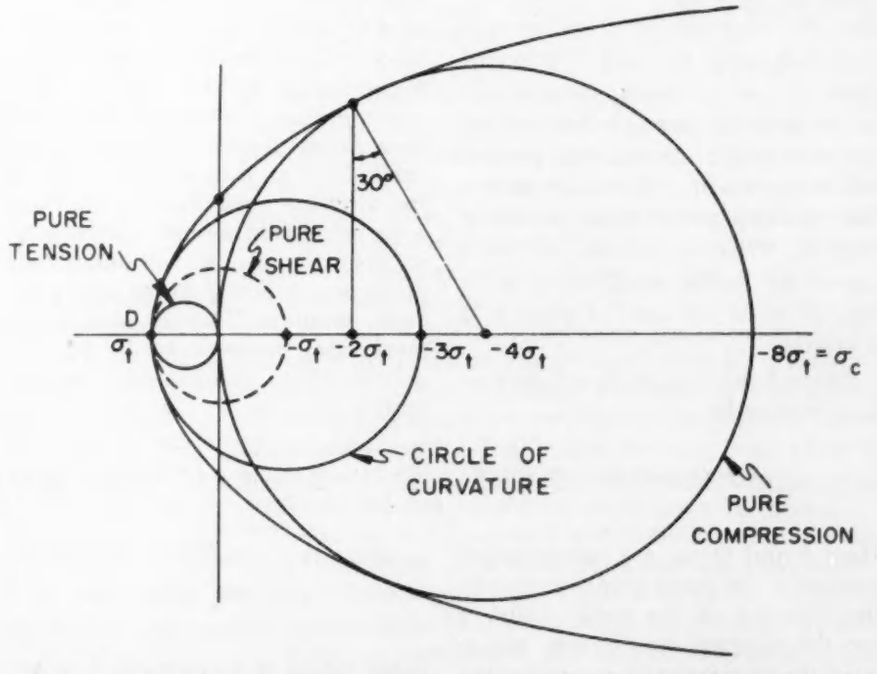

FIGURE 6—Stress circles showing the ratio between σ_c and σ_t for Griffith's hypothesis. The envelope is a parabola.

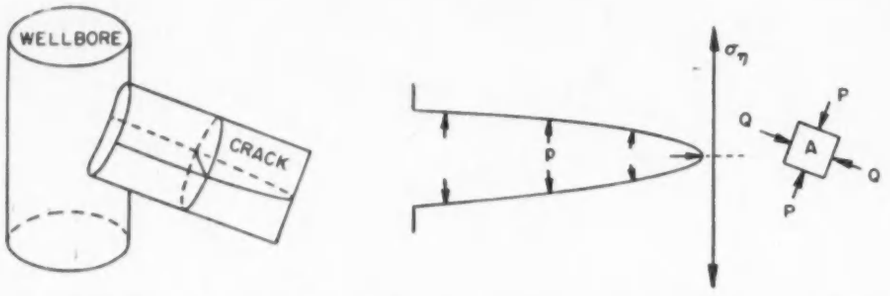

FIGURE 7—(Left) Small crack extending from well bore or central volcanic vent. (Right) Stresses in front of a progressing dike.

About the Author

H. ODE studied geology at the University of Leiden (The Netherlands). After being employed as seismologist by the B.P.M., largest oil operator in Holland, he came to the U. S. in 1950 and joined Shell Development Company, Houston, as a research geologist.

that Griffith's analysis holds approximately.

Let us then apply some of Griffith's results to the analysis of cracks radiating from the well bore. At this moment we need not be concerned with regional stress fields existing in the formation, but we will only remember that the formation is stressed by its own weight. More specifically, it will be assumed that the body forces are constant. Furthermore, it must be assumed that the fluid is of a nonpenetrating kind, that is to say, it does not flow into the small pores of the rock, but stays within the larger cracks. Thus dynamical effects due to fluid motion within the rocks can be excluded.

The state of stress at the wall of a cylindrical hole in which a fluid is resting is such that two principal stresses are horizontal and one is vertical. The vertical principal stress is equal to the weight of the overburden, the tangential principal stress is a tension, and the radial principal stress is a compression. Now it will be assumed that those cracks at whose tips the tensile stresses are greatest will propagate in preference to others. The problem which must be solved then is: What orientation of crack carries the largest tensile stress at its tips, if inside the crack a pressure ρ is exerted?

At the boundary of the ellipse $\xi = \xi_o, \sigma_\eta$ is given by

$$(\sigma_\eta)_{\xi=\xi_o} = \frac{(P+Q)\sinh 2\xi_o + (P-Q)(e^{2\xi_o}\cos 2\eta - 1)\cos 2\psi + (P-Q)e^{2\xi_o}\sin 2\eta \sin 2\psi}{\cosh 2\xi_o - \cos 2\eta}$$

Here P and Q are the two principal stresses in the plane perpendicular to the direction of the crack, ξ and η are the elliptical coordinates, and ψ gives the orientation of the crack (see Figure 4).

If $P = Q$ we obtain:

$$(\sigma_\eta)_{\xi=\xi_o} = \rho - \frac{2P\sinh 2\xi_o}{\cosh 2\xi_o - \cos 2\eta}$$

Let now the medium be stressed only by a pressure P inside the crack. The expression for $(\sigma\eta)\ \xi = \xi_o$ is then obtained by superposition of a hydrostatic pressure ρ on a regional field $P = Q = -\rho$ so that

$$(\sigma_\eta)_{\xi=\xi_o} = \rho - \frac{2\rho\sinh 2\xi_o}{\cosh 2\xi_o - \cos 2\eta}$$

At the tip of the crack ($\eta = 0$) this stress is, for small ξ_o, a very large tension:

$$(\sigma_\eta)_{\xi=\xi_o} = \rho\left[1 - \frac{2}{\xi_o}\right].$$

Consider now a small element of matter close to the tip of the crack (Figure 7) on whose faces the principal stresses are P, Q, and R, where $P < Q < R$. The crack which has the algebraically largest tension in A then situated in the plane which contains Q and R. Thus initial crack extending from the well bore which is perpendicular to the least principal pressure, that is a vertical crack, will have larger tension than any other crack. Such a crack will propagate in the direction prescribed by the large scale stress field around the bore or, in other words, it will follow the plane perpendicular to the least principal pressure. This is exactly the mechanism proposed by E. M. Anderson (1951) postulated for the formation of dikes.

Since this conclusion cannot be verified by direct observation in a drill hole, it is necessary to look for other means of verification. It is fortunate that nature has provided us with large scale hydraulic fracture systems which can be studied. Magma rising in volcanic vents has intruded rocks and formed dikes which became visible after some of the surface layers were eroded. A well-known dike system exists around an intrusive body near Walsenburg, Colo., The Spanish Peaks, in front of the Sangre de Cristo Range. A stress analysis of the dike pattern surrounding the Spanish Peaks was published elsewhere (Odé, 1957) and therefore it suffices to mention only briefly the method and the results of this analysis. It was assumed that the fluid pressure was exerted in a circular hole and that the mountains constituted a large rigid block. Moreover, it was assumed that there existed a stress field in the upper part of the earth's crust, consisting of an East-West compression. These assumptions are sufficient to compute the stress field and it can be shown that the computed stress pattern is in remarkable agreement with the observed pattern of the dikes.

BIBLIOGRAPHY

Howard, G. C., and Fast, C. R. (1950), Squeeze Cementing Operations, *Trans. AIME*, Petroleum Branch, Vol. 189, p. 53-64.

Mohr, O. (1900), Welche Umstande bedingen die Elastizittatsgrenze und den Bruch eines Materiales?. *Z.V.D.I.*, 44, 1524-1572.

Griffith, A. A. (1924), The Theory of Rupture, *Proc. First Int. Cong. Applied Mech.*, p. 55-63, Delft, 1924.

Anderson, E. M. (1951), *The Dynamics of Faulting and Dyke Formation with Applications to Britain*, 2nd Ed., Oliver and Boyd, Edinburgh.

Topping, A. D. (1955), Rock Strength: The Condition of Failure, *World Oil*, 141, p. 109-117.

Orowan, E. (1949), Fracture and Strength of Solids, Reports on Progress in Physics XII, p. 185-232.

Ode, H. (1957), Mechanical Analysis of the Dike Pattern of the Spanish Peaks Area (Colorado). Published in the Bulletin of Geological Society of America, Vol. 68, P. 567-576.

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For Your PRODUCTION File

Part 5 in a series on reservoir engineering

Determining oil lost by a shrinking gas cap

Use this method in reservoir studies when determining if the installation of gas-return facilities can be economically justified.

By Frank W. Cole
Assistant Professor Petroleum Engineering
School of Petroleum Engineering, University of Oklahoma, Norman, Oklahoma

A SHRINKING GAS CAP will cause the loss of substantial oil which might otherwise be recovered. Normally there is little or no oil saturation in the gas cap, if oil moves into the original gas zone there will necessarily be some residual oil saturation remaining in this portion of the gas cap as the oil is produced. The magnitude of this loss may be quite large, depending upon the area of the gas-oil contact, the rate of gas cap shrinkage and the relative permeability characteristics of the reservoir. The difference between the original volume of the gas cap and the volume occupied by the gas cap at any subsequent time is a measure of the volume of oil which has migrated into the gas cap.

If the size of the original gas cap in cubic feet is denoted by G, then the expansion of the original free gas resulting from reducing the pressure from P_o to P is:

$$G v_o \left(\frac{v}{v_o} - 1 \right) \qquad (1)$$

where:

v_o = conversion factor at original pressure, barrels/standard cubic foot
v = conversion factor at any subsequent pressure, barrels/standard cubic foot
P_o = original reservoir pressure, psia
P = pressure at any subsequent time, psia

If the gas cap is shrinking, then the volume of produced gas must be larger than the volume of gas expansion. As mentioned before, all of the oil which moves into the gas cap will not be lost as this oil will also be subject to the various driving mechanisms. There was originally no oil saturation in the gas cap; therefore the oil which will be lost is the residual oil saturation remaining after depletion. The volume of oil lost by a shrinking gas cap then can be calculated by the following equation:

$$\left[g v - G v_o \left(\frac{v}{v_o} - 1 \right) \right] \frac{S_{og}}{\beta S'_{og}} \qquad (2)$$

where:

g = volume of gas produced, standard cubic feet
S_{og} = residual oil saturation in the gas zone, fraction
β = Formation volume factor
S_{og} = Oil saturation in gas zone after invasion = $(1 - C_w - S_{gr})$
C_w = Connate water saturation
S_{gr} = Residual gas saturation in oil-invaded zone

The residual oil saturation remaining in the gas zone can be determined by knowing the relative permeability characteristics of the reservoir and the mechanism by which this oil in the gas cap will be produced. There are four principal methods or combinations of methods by which this oil can be produced:

1. Solution gas drive
2. Future expansion of the gas cap
3. Water drive
4. Gravity drainage

A knowledge of the producing mechanism is essential as there will be a wide variation in the residual oil saturation left by the different driving mechanisms.

Control of the gas cap size is very often a reliable guide to the efficiency of reservoir operation. A shrinking gas cap can be controlled by either shutting in wells which are producing large quantities of gas cap gas or by returning gas (or in some cases water) to the gas cap portion of the reservoir. In many cases, the shrinkage can not be completely eliminated by shutting in wells producing excessive quantities of gas cap gas, as there is a practical limit to the number of wells which can be shut in. The return of fluids, either gas or water, to the gas cap may be the only practical method of eliminating or reducing gas cap shrinkage. The amount of oil lost by the shrinking gas cap can very well be the engineer's most important economic justification for the installation of gas-return facilities. Normally, there must be some economic justification for this relatively large investment.

The terms in Equations 1 and 2 are familiar material balance terms. If there have been any material balance calculations performed on a reservoir, these terms will be readily available. Even though no material balance work has been performed, the data for the terms in the equations are normally not difficult to obtain.

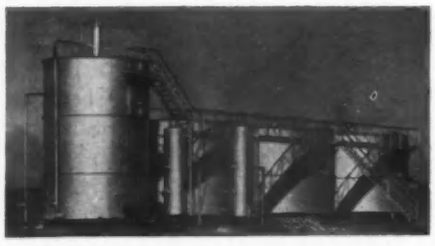
TO BE CONTINUED

Safe production practices save money

Company safety rules can aid the workmen in carrying out their duties safely and will reduce property loss from accidents.

By Ben Adair
Parkersburg Rig and Reel Company
Houston

IN EVERY field operation the main purpose is to complete as much work as possible. This means work must continue without stoppage. Accidents are one of the main causes of work stoppage. Short down to earth safety rules will enable the operator to set up a safety program for more accident free installation and servicing of the production equipment in the field. These rules will cover the installations in the field that are dangerous to roustabouts and expensive to the operator. Most accidents can be prevented.



Bolted Tanks

Bolted tanks will be considered first as they are widely used in the oil fields today. These tanks must be cleaned, repaired and painted. In doing this work certain rules must be followed. The cleaning should be scheduled to enable the operator and cleaning crew to coordinate the work and save time for this operation. When it is necessary for unscheduled repairs the same rules should be followed as when a regularly scheduled job is done. The main rules to follow are:

1. Empty the tank. This means removal of residue in the bottom of the tank or in any depressions, sumps or cones.
2. Allow the tank to air.
3. Never cut flange openings in tanks that have not been emptied and aired. The use of bronze or spark-proof tools is not sufficient protection for the workmen.
4. Be sure the proper equipment is available for use before starting a job.
5. See that the proper clothing is being worn. Safety shoes are a *must* on a tank job, both the safety toe and the non-slip soles.
6. Never require work to continue in the rain or other adverse weather conditions.
7. Scaffolds should be checked throughout. Scaffold boards become defective and must be kept free of grease. Ropes with knots are dangerous.
8. Provide gin poles for lifting.
9. All hand tools should be in good repair. Safety goggles should be worn when chipping and hammering.
10. Never enter a tank without the proper respiratory equipment and always have a stand-by man.
11. When working around petroleum storage of any type, remember, "No Smoking" or open fire.

Welded tanks are to be treated the same as bolted tanks.

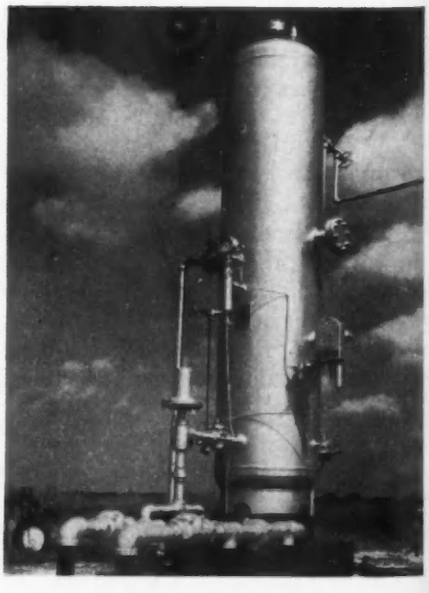
Wooden tanks are used in some fields. The same precautions must be observed plus some that are peculiar to these tanks.

1. Turn all nails down to prevent their sticking and tearing. Better still remove them if possible.
2. Splinters are to be avoided or, immediate first aid treatment must be administered.
3. Steam and air this type of tank where possible.

Pressure Vessels

Due to the shape and size of pressure vessels used in the production of oil, transport and installation is always a problem. The basic rules for these operations could be applied in almost any type of moving and erection of any object, with hard to handle shape, size and length. Specifically, with heaters, scrubbers, separators and the various other pressure equipment used in the oil field the following basic safety rules apply:

1. Use adequate transport. Don't cut down the size of a truck or trailer if smaller size is doubtful. A truck that is loaded to capacity might not have trouble on good smooth high-



ways, but very few good smooth roads are in the oil fields.

2. Check the unloading equipment, replace all worn or damaged parts. A falling vessel endangers everyone.

3. Foundations must be adequate to support the load of the vessels to be erected.

4. Guy wires should be straight and unkinked and any strand breakage should cause the wire line to be replaced.

5. Riding of the vessels during unloading and erecting should not be allowed.

6. On high pressure vessels, the fitting should all be of high pressure type. Check this carefully before using the fittings.

7. In hooking up a fired pressure vessel never connect a line from a safety valve into the flue vent line.

8. Back pressure valves should always be checked for proper working order.

9. Be careful of opening high pressure vessels into vessels of lesser strength. Make sure the low strength vessels are open to flow.

10. Be careful that the safety head discs are not near or equal to the vessel's hydrostatic test pressure. The safety head should be sized to relieve 100 percent of gas capacity at vessel design pressure.

11. Hydrostatic test all flow lines.

12. If the equipment has been in operation, vent all the gas pressure from the vessel and piping before working on it.

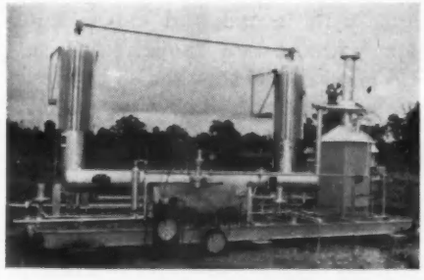
13. When installing a new vessel next to an operating unit, the operating unit should be depressured during this installation.

14. Do not use a vessel as an anchor for a block and tackle. The design of the vessel is for an internal load. Any outside pressure might cause a failure. Never try to move a vesse! while it is in operation.

15. Before removing safety shield from liquid level gage glass, always close cocks and bleed the pressure.

16. Safety valves should be provided to relieve temporary pressure surges or temporary excess flow rates. Safety valves should be tested on start up and at least once a year to insure proper functioning at all times.

Personal carelessness such as smoking around open separation gas or oil may cause your death.



Fired Vessels

Fired vessels found in the field today are a major danger both to the workmen and wells. Proper respect for their danger possibilities may save a man and a well.

Certain rules are applicable to the fired vessels by the very nature of their process. They are as follows:

1. A minimum distance of 150 feet from the wellhead and tanks to any fired vessel should be maintained at all times. This is the case for all fires of any type. The heater treater may have leakages that would enable a fire to start at any time. Sufficient distance to minimize danger is 150 feet.

2. When firing a vessel, checks should be made for gas accumulation.

3. All fittings should be checked and pressure relief valves on all direct fired vessels checked.

4. Make sure to check the amount and condition of water. Failure to do so may cause fire tube hot spots resulting in burn out, blow out and fire.

5. Check the bil safety trap in the supply gas line to prevent oil accumulation in heater burner.

6. Never tie a safety relief line to the gas tank or water line. They must be separate.

7. In hooking up a fired vessel do not tie any lines to live lines until the job is complete.

8. In case a special drain box is put on a treater to catch samples from oil-water interface pet cocks, a check valve and gate valve should be put in the line if tied into the water damp line, to prevent blow back to the drain box.

9. When entering closed buildings where the heater is housed, the operator should at all times see that cigarettes, pipes and other fires are extinguished.

10. Always pipe stripper exhaust to a pit 50 to 100 feet from the reboiler.

11. The flue supply gas safety valve should never be piped into the distributive exhaust lines.

12. The safety valves on these vessels should be checked when first started up and at least once a year thereafter.

13. The safety valve on the supply gas should be checked when the unit is started up and at least once a year thereafter.

14. When lighting the burner, do not put your eyes close to the lighting hole.

15. Replace high pressure flexible hose on these vessels at least once a year.

The adsorption units in present day oil fields incorporate as much safety as possible. The heater used with this equipment is usually a direct fired type. As many safety devices as practical are incorporated in these heaters. If the unit is ever to be shut down, by-passed or worked on in any way that will stop the flow of the regeneration gas, the heater must be turned off first. Any time the unit is found with no regeneration flow, the heater must be turned off at once.

These units operate at extremely high temperatures, therefore, never touch any fitting valve or open spots in the insulated lines with bare hands. If units are operated at pressures higher than designed capacity, there should be safety heads installed in the system upstream of the unit as well as a regulator set up in the system. Additional regulator or high-low pressure valve arrangement should be provided that will shut in the flow if the safety head blows. Only where the danger of vessel failure is serious as shown above are knock-out or up-stream safety heads desirable, as they can create a dangerous situation if they fail.

While working on pressure vessels, show proper respect, use safety equipment provided and always have a stand-by man. Pressure vessels are designed for a maximum operating pressure and temperature. Make sure these vessels are operated within the designed pressure and temperatures.

Pay attention to corrosion both external and internal. Corrosion may cause high pressure stoppage or may weaken the vessel.

Most accidents happen because the men are so familiar with their work they lose respect for its dangers. The best way to prevent accidents is to *think*. The best safety device is located just above your shoulders. Use it! —**The End**

the generalized Kozeny-Carman equation

Its application to problems of multiphase flow in porous media

Part 2—a novel approach to problems of fluid flow

A capillaric model for a porous medium, combined with a random interconnection of pores, leads to a simple statistical theory. The tortuosity factor receives a new significance.

By M. R. J. Wyllie and G. H. F. Gardner
Gulf Research and Development Company, Pittsburgh, Penn.

A New Model of a Porous Medium. The physical complexity of a porous medium makes it virtually mandatory that some simplified model be assumed if qualitative and, particularly, quantitative predictions are to be made of flow behavior in the medium. An examination of the original Kozeny-Carman model and its modifications has shown that, though useful, a primary difficulty lies in the proper understanding of the significance of the parameter called tortuosity.

Scheidegger has suggested[3] that a statistical approach to the problem of fluid flow in porous media be used because it avoids the shortcomings of capillaric models. Unfortunately he has not as yet been able to carry the purely statistical approach to any point of practical usefulness. The capillaric model considered below combines the essential features of a number of previous models (e.g., Burdine et al,[10] Purcell[18] and Wyllie and Spangler[8]) and, at the same time, incorporates some elementary statistical theory to elucidate the toruosity factor. The justification for any model must lie in the agreement between predictions made with its aid and experimental observations. In this regard the new model seems surprisingly satisfactory. A good model should also be simple and, above all, internally consistent. These criteria also appear to be met.

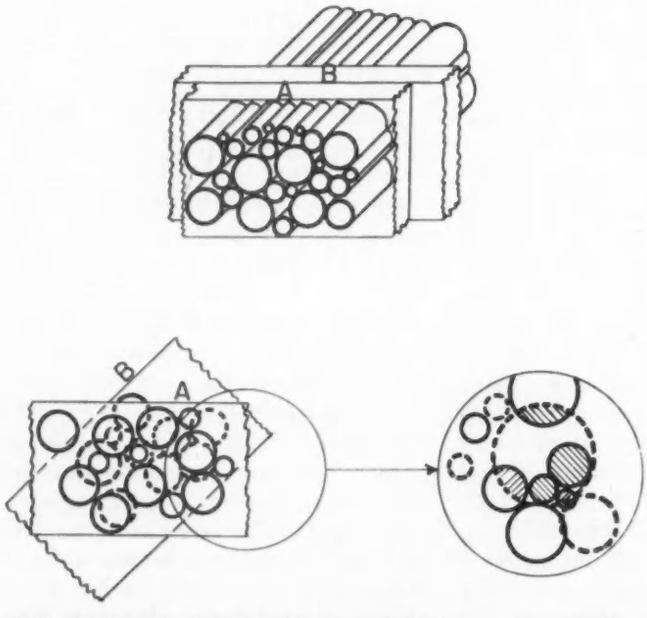
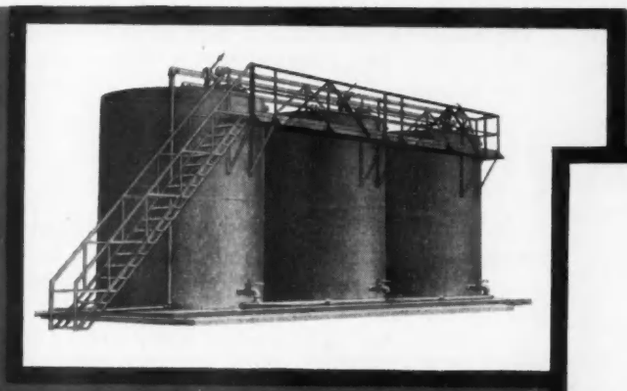


FIGURE 3—Idealized capillary model of a porous medium showing probability of interconnection (tortuosity) factor.

Consider a bundle of capillary tubes whose radii are given by the distribution function $\alpha(r)$. That is, there are $\alpha(r)dr$ capillaries whose radii lie between r and r+dr. Let the smallest radius be r_1 and the largest r_2. Suppose that this bundle is cut into a large number of thin slices. Let the short pieces of tube in each slice be arranged randomly and then let the slices be reassembled. The resulting structure is the physical model of a porous medium imagined.

It is known that there can exist an immobile wetting phase saturation S_{wi} in a real porous medium. This liquid is held primarily as pendular rings at grain contacts and in interstices. In our model we do not envisage any such immobile fluid; the displacement of liquid from any pore is considered to be complete. To establish the relation between an actual porous medium and the model our first step is to remove effectively the residual wetting phase saturation. Imagine that the immobile, irreducible fluid in the prototype is solidified and turned to stone. This modifies the structure of the original medium so that the irreducible saturation is now zero and this modified medium is compared with the model.

If S_{wi} denotes the irreducible wetting phase saturation, then the porosity of the modified medium is given by ϕ^*, where $\phi^*=\phi(1-S_{wi})$. Similarly, if S_w denotes the actual wetting phase saturation, then the corresponding saturation in the model is denoted by S_w^*, where $S_w^*=$



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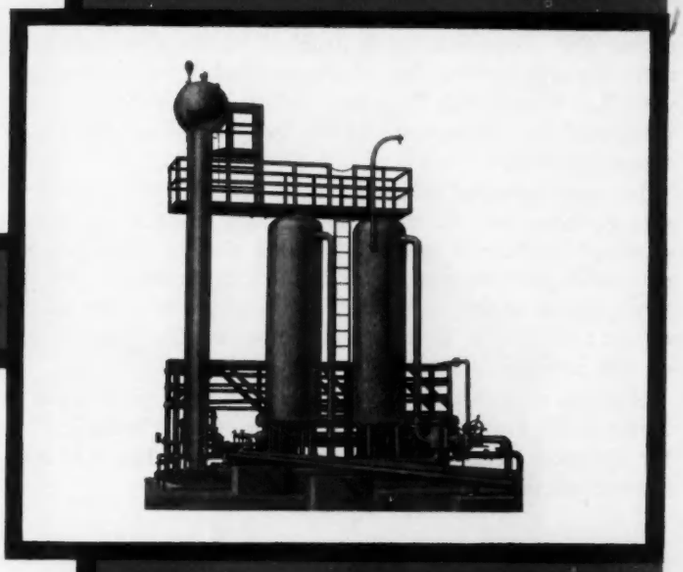

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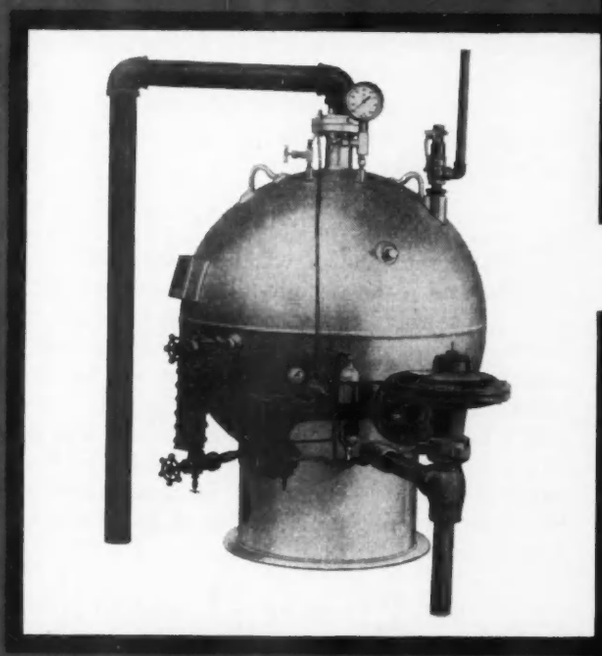

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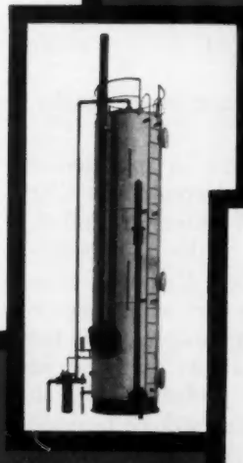

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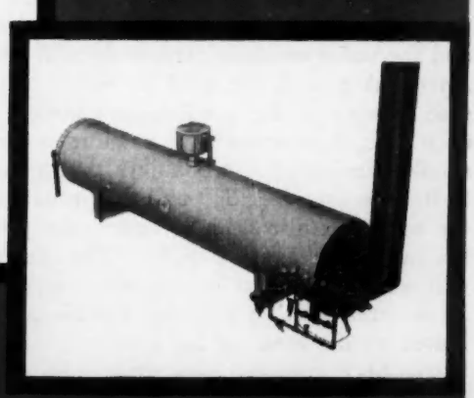

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$(S_w—S_{wi})/(1—S_{wi})$. Consequently, the complementary non-wetting phase saturation in the model is $S_o^*=S_o/(1—S_{wi})$.

It is assumed that the permeability of the modified medium is equal to the permeability of the original medium. This simplification is justified by the close agreement between nonwetting phase permeabilities measured with $S_w=0$ and with $S_w=S_{wi}$. Hence the permeabilities calculated from the model are directly applicable to the actual medium.

It is also assumed that if P_c is the actual capillary pressure at saturation S_w then the capillary pressure for the modified medium at saturation S_w^* is also P_c. This seems reasonable because the customary measurement of capillary pressure is dominated by the resistance to entry into a pore and the size of this entry is not strongly dependent on the irreducible saturation.

Suppose that at a capillary pressure P_c the actual saturation is S_w. Corresponding to this situation it is assumed for the model that the saturation is S_w^* and that gas has entered all pores larger than a size defined by

$$R=\frac{2\gamma}{P_c} \tag{14}$$

The wetting phase saturation S_w^* is related to the radius R and the pore size distribution by the equation

$$S_w^*=\int_{r_1}^{R}\pi r^2\alpha(r)dr \Big/ \int_{r_1}^{r_2}\pi r^2\alpha(r)dr \tag{14a}$$

Hence, from a measured capillary pressure curve, the distribution $\alpha(r)$ may be calculated.

The area effectively occupied by water in any slice of the model is $\phi S_w^* A$ where A is the total area of the slice and the water occupies pores with radii between r_1 and R. An equal area is occupied by water in the neighboring slice. Owing to the random distribution of the pores in each slice, these areas have a common part whose area is smaller. Indeed, the probability that a random point lies in the first area is $\phi^*S_w^*$ and the probability that it lies in the second is also $\phi^*S_w^*$; hence the probability that it lies in both areas is $(\phi^*S_w^*)$.[2] The idea will be pursued that static properties of the water phase are dominated by the area $\phi^*S_w^*A$ whereas dynamic properties are dominated by the area $(\phi^*S_w^*)^2A$.

Consider a single pore filled with water. This pore abuts against pores in the next slice of which some are filled with water also. Assuming that the water-filled pores are randomly distributed, it follows, by a similar argument, that the area common to the *single* pore in the first slice and all the water-filled pores may be taken as $\pi r^2\phi^*S_w^*$.

Thus the water passes through a pore whose area is πr^2 but whose ends are constricted to a fraction $\phi^*S_w^*$ of this area. The water flux through this pore is clearly less than it would be if this impedance did not exist but greater than it would be if the pore were restricted over its entire length. It is also influenced by the way in which the exit area is distributed over the ends of the pore.

Sketches which may assist in visualizing the concepts presented are given as Figures 3 and 4.

Since the flux of water through a constricted pore depends on the distribution of the exit area, it can only be expressed on the basis of an average distribution. Imagine that the constricted pore is equivalent, on the average, to a pore or pores of smaller radius. Since for all pores the exit area is taken as $\phi^*S_w^*$ times the sectional area of the pore, it seems reasonable to expect that the radius of the equivalent pore is proportional to $(\phi^*S_w^*)^{1/2}$.

We therefore write

$$\bar{r}=\frac{(\phi^*S_w^*)^{1/2}}{n^{1/2}}r \tag{15}$$

where $\bar{r}$ is the radius of the equivalent pore and n is a numerical constant that reflects the manner in which the available interconnecting pore area is divided. See Figure 4. In the most favorable case for flow, all the exit area is concentrated in one pore; then n = 1. It may be expected, therefore, that $n \geqq 1$.

It may also be expected that n will depend upon the distribution of radii $\alpha(r)$ and thus vary from one porous medium to another. In any particular medium it will be assumed that n is the same for all pores, i.e., that the geometry of the pores and their interconnections does not depend on their size.

Poiseuille's law is used to calculate the flow of water through each pore on the assumption that the effective radius is given by Equation (15).

$$Q=\frac{P\pi}{8\mu}(\phi^*S_w^*)^2 r^4\frac{\beta}{n^2}n \tag{16}$$

Here Q is the flow of water in cc/sec, P the pressure gradient and μ the viscosity. The parameter β is inserted to recognize the fact that flow through a tube of radius r overemphasizes the impedance since it ignores the larger areas available for flow at either side of the constrictions formed where tubes abut. Thus it may be expected that $\beta \geqq 1$ and that the actual magnitude of β is a function of the average shape of pores in the medium which the model represents. The effect is qualitatively shown in Figure 4. Summing the flow through pores with radii from r_1 to R gives

$$Q=\frac{P\pi}{8\mu}(\phi^*S_w^*)^2\frac{\beta}{n}\int_{r_1}^{R} r^4\alpha(r)dr \tag{17}$$

if it is assumed that neither n nor β are a function of pore size.

The total area A of the cross-section may be written in terms of the distribution $\alpha(r)$.

$$\phi^*A=\int_{r_1}^{r_0}\pi r^2\alpha(r)dr \tag{18}$$

Then the flux Q/A is obtained from Equations (17) and (18) in terms of the distribution $\alpha(r)$.

If S_w^* denotes the saturation corresponding to a radius r then, by differentiating Equation (14a) and replacing R by r, we have

$$dS_w^*=r^2\alpha(r)dr \Big/ \int_{r_1}^{r_2} r^2\alpha(r)dr \tag{19}$$

Eliminating r from Equation (17) by using Equations (14) and (19) the flux Q/A becomes

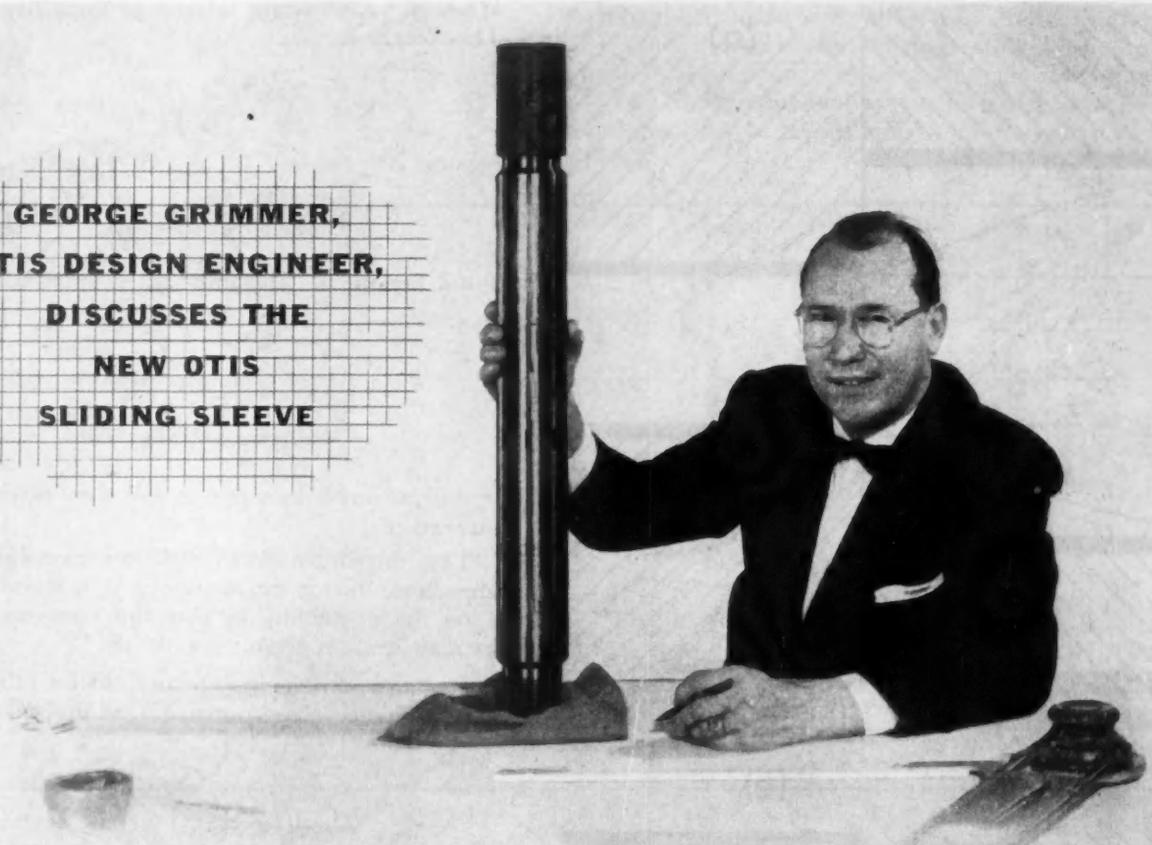
$$Q/A=\frac{\gamma^2P\phi^*}{2\mu}(\phi^*S_w^*)^2\frac{\beta}{n}\int_0^{S_w^*}\frac{dS_w^*}{P_c^2(S_w^*)} \tag{20}$$

Comparing Equation (20) with Darcy's Law gives the effective permeability Kk_{rw} as

$$Kk_{rw}=\frac{\gamma^2}{2.0}\phi^*(\phi^*S_w^*)^2\frac{\beta}{n}\int_0^{S_w^*}\frac{dS_w^*}{P_c^2(S_w^*)} \tag{21}^*$$

*The numerical constant 2.0 indicative of circular capillaries may be replaced, for greater generality, by k_o.

GEORGE GRIMMER, OTIS DESIGN ENGINEER, DISCUSSES THE NEW OTIS SLIDING SLEEVE



"Now a well can be set up with full-opening Otis side-door equipment"

Q. George, why is a full-opening tool desirable?

A. Well, with a sliding sleeve type side-door, the ports can be closed or opened, allowing a full opening for flow and wire line tools — with or without communication to the annulus.

Q. What are some of the major features of the Otis Sliding Sleeve?

A. For one thing, we can open or close all sleeves in the string with one trip of the shifting tool . . . or we can "selectively" shift a single sleeve. Also that there is no doubt that the sleeve shifts; the shifting tool will not pass through the sleeve — either up or down — until the sleeve *is* shifted. Another feature is that we can use the sleeve with Otis S Equipment.

Q. In other words, it broadens the use of the Type S Otis Landing Nipple?

A. Yes. Used with S Equipment, the sleeve can serve all of the purposes of a side-door choke. By itself, it can be used in single-string selective completions, to produce several zones selectively; as a circulating sleeve; as a well killer, and in permanent completions.

Q. Is the tool outsized — I mean large-diameter?

A. No indeed. It is collar-diameter, which is extremely desirable for parallel-string completions.

Q. I understand the Otis sleeve is pretty rugged.

A. It's a lot more than it needs to be. On test, we put a strain on it equal to twice the yield strength of N-80 tubing and the sleeve shifted O.K. We use a non-vulcanizing, non-swelling V-type packing, too.

Q. What about equalizing pressure differentials as the sleeve is shifted?

A. The tool has equalizing ports as well as flow ports. It is easily equalized, which prevents damage to the packing, even with high differentials. Incidentally, we have 1¼ square inches of flow area through the ports . . . considerably larger than the area in a choke.

Q. George, will this equipment replace the Otis Side-Door Choke we've used for so many years?

A. Not entirely; the Sliding Sleeve will have certain advantages in some wells, and vice versa for the Removable Side-Door Choke. I would suggest that operators check with one of our many branch offices for a competent recommendation.

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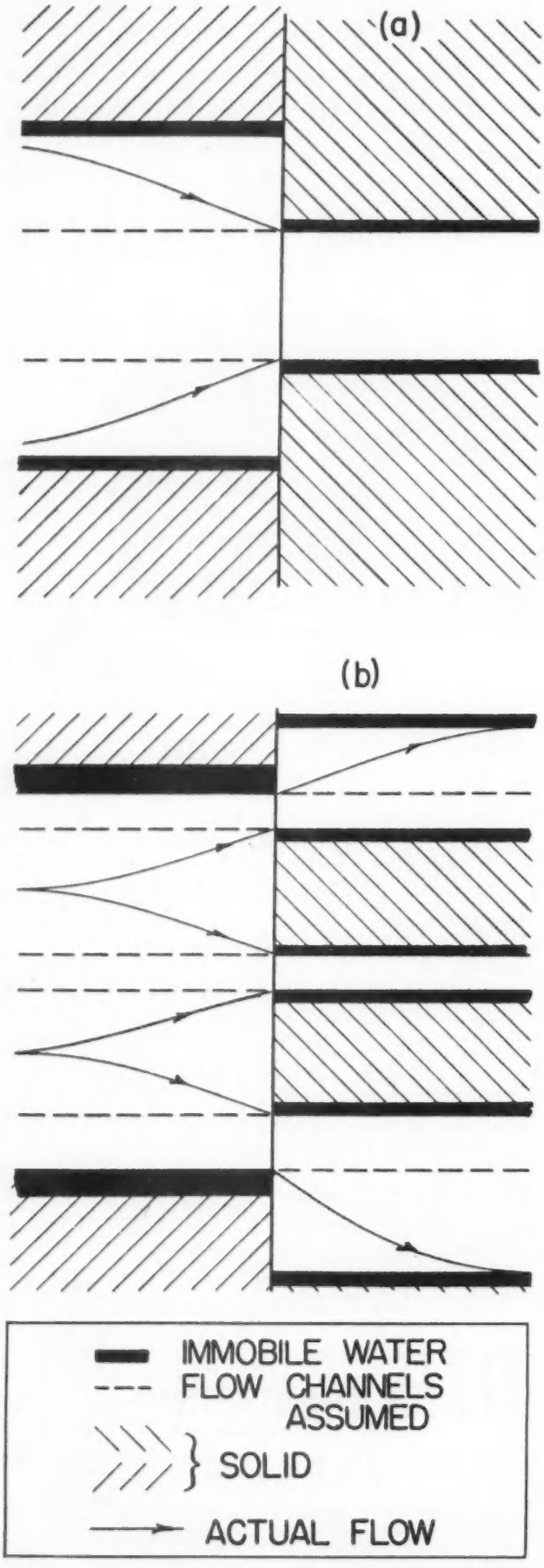

FIGURE 4—Schematic representation of values of geometrical factors β and η in (a) $\eta = 1$, in (b) $\eta > 1$.

When S_w^* is unity the relative permeability k_{rw} is unity. Therefore,

$$K = \frac{\gamma^2}{2.0}\,\phi^{*3}\,\frac{\beta}{n}\int_0^1 dS_w^*/P_c^2 \qquad (22)$$

or

$$K = \frac{\gamma^2}{2.0}\,\phi^3\,\frac{\beta}{n}\,(1 - S_{wi})^2\int_{S_{wi}}^{1.0} dS_w/P_c^2 \qquad (22a)$$

From Equations (21) and (22) it appears that

$$K_{rw} = (S_w^*)^2\,\frac{\int_{S_{wi}}^{S_w} dS_w/P_c^2}{\int_{S_{wi}}^{1.0} dS_w/P_c^2} \qquad (23)$$

if it is assumed that β/n is not a sensitive function of saturation.

Thus the simple model leads to the conclusion that the impedance factor or tortuosity is primarily dependent upon the probability of pore interconnections and that its magnitude is approximately $(S_w^*)^2$.

Similar equations may be derived for other phases. In the terminology used previously, as shown in Figure 2,

$$k_{ro} = \left(\frac{S_L - S_w}{1 - S_{wi}}\right)^2\,\frac{\int_{S_w}^{S_L} dS_w/P_c^2}{\int_{S_{wi}}^{1} dS_w/P_c^2} \qquad (24)$$

$$k_{rg} = \left(\frac{1 - S_L}{1 - S_{wi}}\right)^2\,\frac{\int_{S_L}^{1.0} dS_w/P_c^2}{\int_{S_{wi}}^{1} dS_w/P_c^2} \qquad (25)$$

Use of New Model to Predict Electrical Parameters. If it is assumed the resistance to the flow of electricity in the model is dominated by the exit area from each pore, it is possible to calculate the resistivity index in a manner analogous to that used to compute relative permeability.

Then in a unit length of model of unit cross-sectional area the conducting fluid in the pores (here taken to be a wetting phase) has a unit length and an effective cross-sectional area $(\phi S_w)^2$. Here the actual saturation S_w is used and not the reduced saturation S_w^* because of the experimental observation that when the saturation is S_{wi} the water, although physically immobile, is electrically conductive. In Figure 4, therefore, the solidly shaded areas are part of the channels in which current flows. Letting R_o denote the resistance of a unit length of conducting fluid of unit cross-sectional area, the resistance R of the fluid within the model is given by

$$\frac{R}{R_o} = (\phi S_w)^{-2} \qquad (26)$$

The formation factor F is obtained by letting S_w equal unity. This gives

$$F = \phi^{-2} \qquad (27)$$

Similar formulae may be derived for a conducting non-wetting phase.

The resistivity index I is given by the ratio of Equations (26) and (27), i.e.,

$$I = \frac{R}{R_o F} = S_w^{-2} \qquad (28)$$

Equation (27) must represent a *maximum value for F at any porosity* since the entire length of all capillaries in the model was assumed to have an area available for conduction equal to the mutual contact area only. This oversimplification can be compensated by introducing a geo-

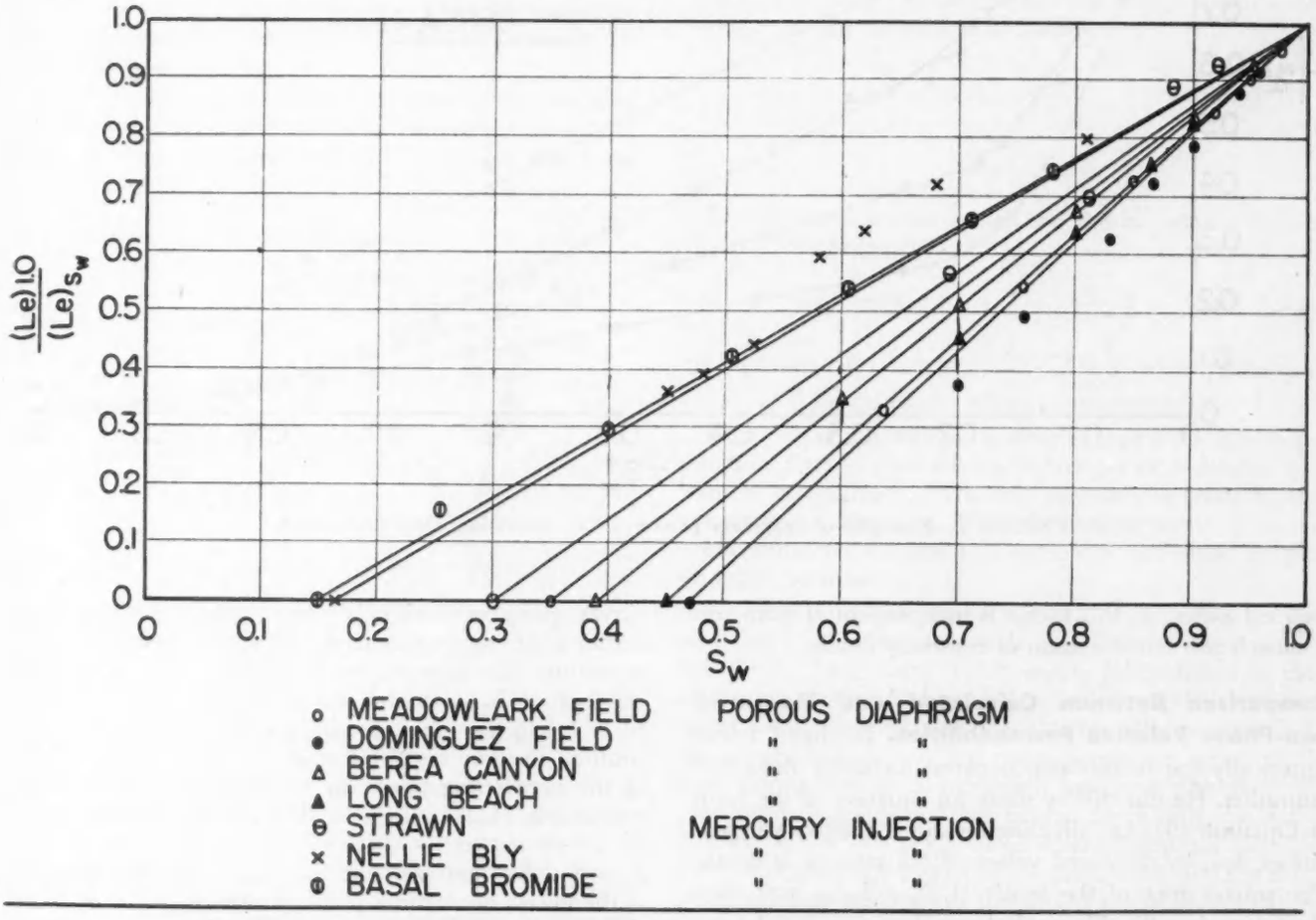

FIGURE 5—Plot of (impedance)$^{1/2}$ vs. wetting phase saturation data of Burdine Ref. (16).

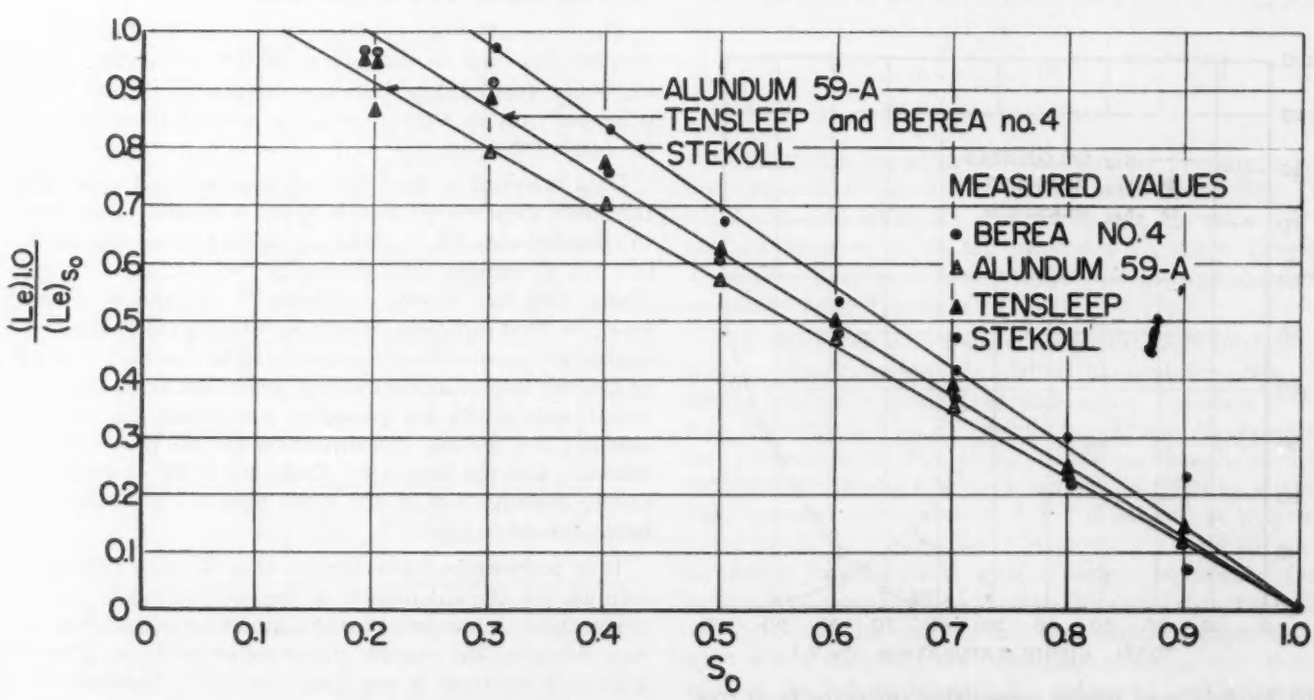

FIGURE 6—Plot of (impedance)$^{1/2}$ vs. non-wetting phase saturation.

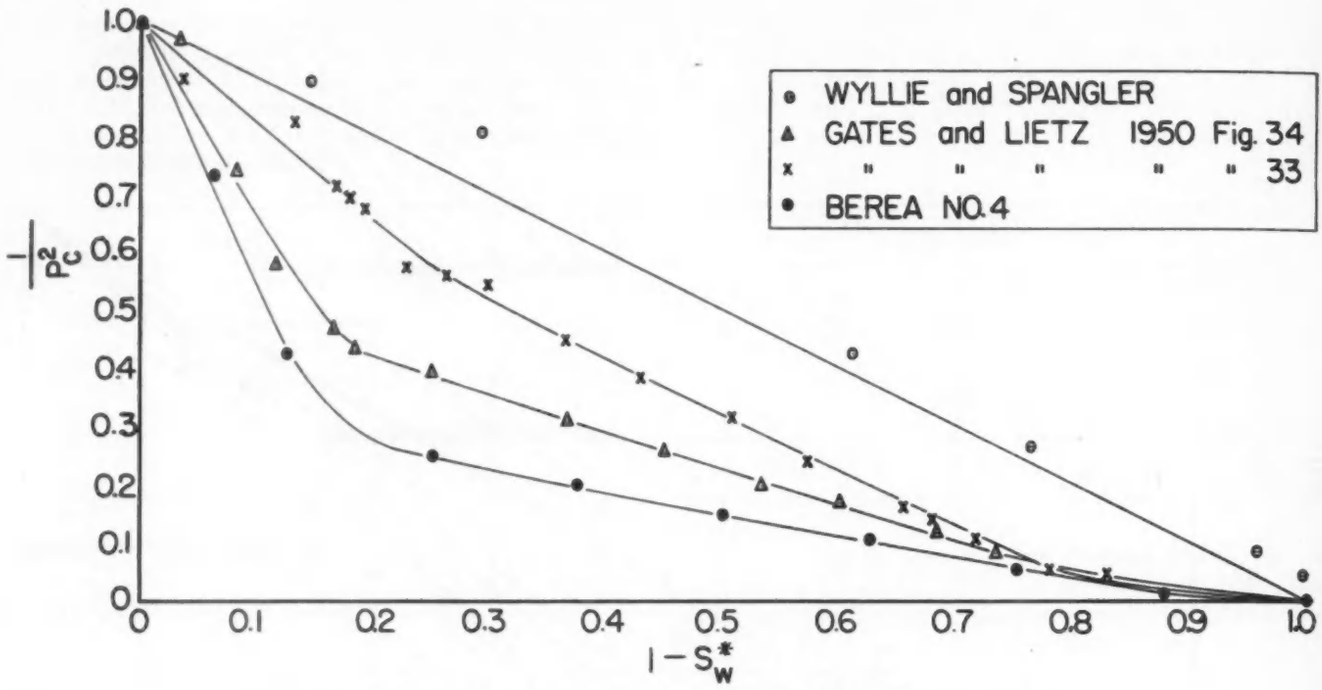

FIGURE 7—Examples of (capillary pressure)$^{-2}$ vs. saturation. Data normalized.

metrical factor. If this factor is independent of pore size it cancels in the calculation of resistivity index.

Comparison Between Calculated and Measured Two-Phase Relative Permeabilities. Burdine[16] found empirically the relationship between tortuosity ratio and saturation. He did this by using an equation of the form of Equation (9), i.e., dividing measured relative permeabilities, k_{rw}, by measured values of the ratio of integrals. The square root of the result $(L_e)_{1.0}/(L_e)_{sw}$ was then plotted against S_w. Figure 5 shows data calculated from

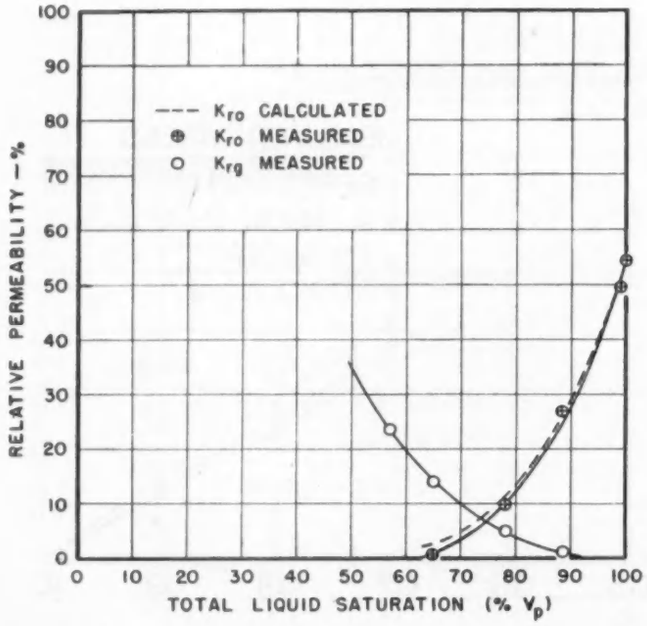

FIGURE 8—Gas-oil relative permeability curves for Berea core 10, 38.8 percent brine saturation.

curves given in Burdine's paper. While there is some scatter of points, deviations do not appear to be systematic in nature. The general trend appears to be for the plot of $(L_e)_{1.0}/(L_e)_{sw}$ to fall on a straight line connecting $S_w = 1.0$ to $S_w = S_{wi}$, the irreducible wetting phase saturation. Burdine suggested that the ratio $(L_e)_{1.0}/(L_e)_{so}$ of the nonwetting phase lay similarly on a straight line connecting $(L_e)_{1.0}/(L_e)_{so}$ with S_o. Here the line was to be drawn between a value of $(L_e)_{1.0}/(L_e)_{so}$ of unity at $S_o = 1 - S_{wi}$ and zero at $S_o = S_m$. The saturation S_m is the lowest nonwetting phase saturation at which continuity of the phase is maintained. In general the value of S_m is not greatly different from zero.

The experimental evidence adduced by Burdine to support this view of the nature of the nonwetting phase tortuosity relationship was not adequate; it was based principally on an analogy with the wetting phase tortuosity relationship.

Data obtained in the Gulf Laboratories tend to support Burdine's view except that it appears equally satisfactory to consider that $(L_e)_{1.0}/(L_e)_{so}$, when plotted against S_o, falls on a straight line joining $S_o = 1 - S_{wi}$ to $S_o = 0$. These data are shown in Figure 6. It cannot be said, however, that sufficient experimental data are available to enable any unequivocal conclusion to be reached. The use of Corey's approximate method, to be described, has been found satisfactory for practical use. Since this method obviates the tedious determination of the pore size distribution and the integration under the $1/P_c^2$ — saturation curve, investigation of the more rigorous procedure has been allowed to lapse.

It is noteworthy, nevertheless, that Burdine's proposed formula for the calculation of the wetting phase relative permeability is precisely that obtained by application of our new model to the relative permeability problem. That is, Burdine's equation is our Equation (23). Similarly Burdine's proposed equation for nonwetting relative phase

permeability is our Equation (24) if $S_m = 0$. The relatively simple model assumed thus leads to expressions for the impedance or tortuosity factor which appear to be substantially in agreement with the experimental data available.

Corey[17] suggested that Equations (23) and (24) would be more convenient to use if it were not necessary to determine directly either the capillary pressure curve or the irreducible saturation S_{wi}.

If the nonwetting phase relative permeability is measured directly (and this is experimentally simple to do), it should be clear from Equations (23) and (24) that these measurements must reflect the nature of the capillary pressure curve. Since

$$\int_{S_{wi}}^{S_w} dS_w/P_c^2 + \int_{S_w}^{1.0} dS_w/P_c^2 = \int_{S_{wi}}^{1} dS_w/P_c^2$$

it is easy to show (Wyllie[15]) that the relative permeabilities k_{rw} and k_{ro} are related as follows:

$$k_{rw} = \frac{1 - k_{ro}\dfrac{(L_e)_{So}}{(L_e)_{1.0}}}{\dfrac{(L_e)_{Sw}}{(L_e)_{1.0}}} \qquad (29)$$

On the basis of our model and the impedance factors it yields, this becomes

$$k_{rw} = (S_w^*)^2 - k_{ro}\left(\frac{S_w^*}{1 - S_w^*}\right)^2 \qquad (30)$$

In Equation (30) $S_w^* = \left(\dfrac{S_w - S_{wi}}{1 - S_{wi}}\right)$ which, following Corey, will be called the effective saturation.

From Equation (30) it is evident that if k_{ro} is experimentally found (generally for an oil-gas or water-gas system for convenience), it is only necessary to know S_{wi} to compute k_{ro}. However, while the measurement of S_{wi} is often considered routine, it is not in our view either simple or rapid to make.

In order to avoid measuring capillary pressure curves and the irreducible saturation S_{wi}, Corey[17] drew attention to the fact that $1/P_c^2$ is nearly proportional to the saturation, except at high saturations, for many consolidated rocks. Examples of the plot of $1/P_c^2$ against S_w^* are shown in Figure 7. For convenience, the curves have been normalized by a numerical factor so that they all pass through the same end points. Since only the ratio of areas under the $1/P_c^2$ curve enters Equations (23) to (25), the calculated relative permeabilities are not sensitive to small changes in the actual shape of the capillary pressure curve.

On the basis of a linear relation between $1/P_c^2$ and S_w^* Equations (23) and (24) become

$$k_{rw} = (S_w^*)^4 \qquad (31)$$

$$k_{ro} = (1 - S_w^*)^2\,[1 - (S_w^*)^2] \qquad (32)$$

Without any knowledge of the capillary pressure curve these equations contain the unknown parameter S_{wi}. To select the best value for this parameter Equation (32) may be adjusted to fit the measured k_{ro} curve closely. Then the k_{rw} curve, which is difficult to measure, may be calculated from Equation (31).

This technique is in routine use in the Gulf companies for the determination of relative permeability data. A simple graphical method of comparing Equation (32) with the measured k_{ro} determines S_{wi}. It may be observed that the parameter, S_{wi}, found in this way may be identified with the irreducible water saturation given by a capillary pressure curve only if $1/P_c^2$ is accurately proportional to S_w^*. Otherwise it is merely an empirical parameter introduced to give a simple technique. On hundreds of samples of rock taken from oil fields throughout the world this method has been checked experimentally. When the rocks are reasonably isotropic the agreement of the calculated with the measured wetting phase relative permeability is found to be within the limits set

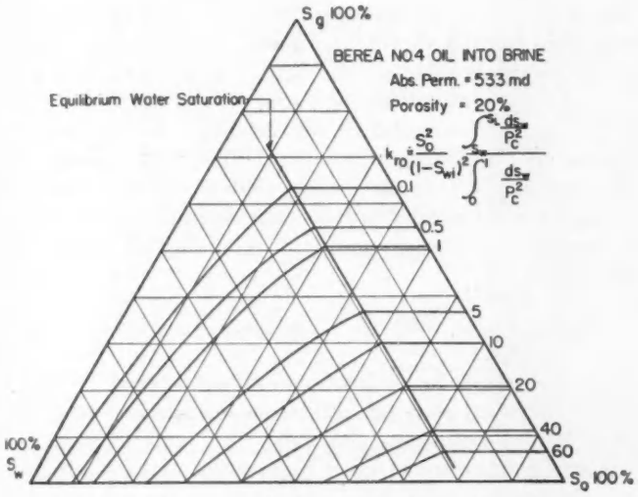

FIGURE 9—Plot of oil isoperms for Berea Sandstone.

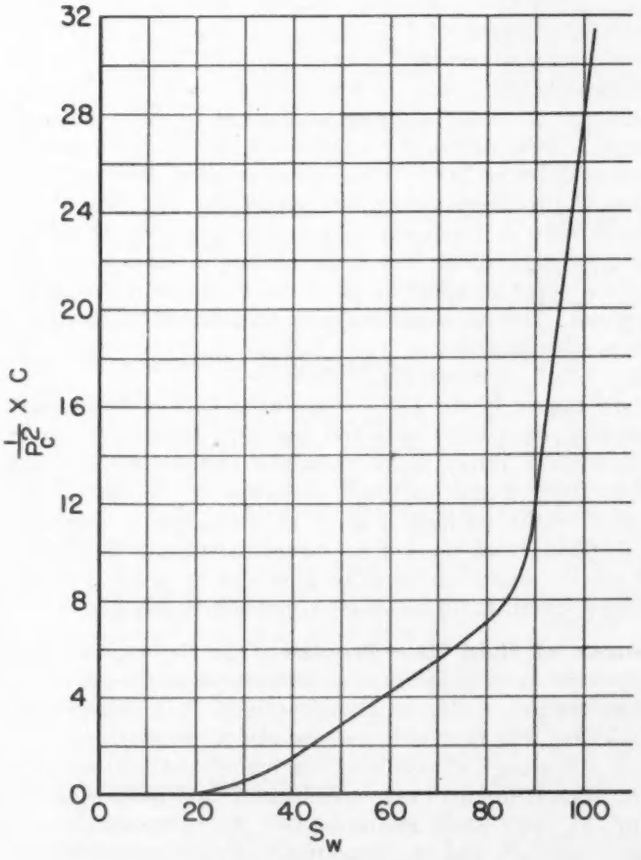

FIGURE 10—Berea 4 oil into brine.

by experimental error. When rocks are stratified the agreement is less satisfactory although frequently surprisingly good. The effect of stratification has recently been discussed by Corey and Rathjens.[19]

The use of Equations (31) and (32) has been validated only for consolidated rocks. Insufficient data are available to test them for unconsolidated sands but there is reason to expect that a modification is necessary.

Calculation of Three-Phase Relative Permeabilities. The model of a porous medium selected lead to Equations (23), (24) and (25). These equations give expressions for the relative permeabilities of a porous medium to a wetting liquid, a nonwetting liquid and a gas when the fluid saturations are obtained on a drainage cycle. Limited experimental verification of these equations has been made.[20] An example of the agreement between the measured and calculated relative permeability of a Berea sandstone sample to oil is shown in Figure 8. The relative permeabilities of this rock to water (the wetting liquid phase) and gas were found to depend only on the water and gas saturations. Such a result is a consequence of Equations (23) and (25); it differs from the early experimental findings of Leverett.[21] While it cannot be proven, it is not unreasonable to assume that Leverett's data were complicated by oil partially wetting the sand grains used.

In Figure 9 is shown a plot of oil isoperms—that is, lines of constant relative permeability to oil—for Berea sandstone. The isoperms are calculated from Equation (24) and are plotted, for convenience, on trilinear paper.

The data of Figure 9 were computed by integrating under the $1/P_c^2$—saturation plot of a typical Berea sandstone. The plot is shown in Figure 10. The value of S_{wi} of the specimen selected was 0.19, the porosity 0.20 and the absolute permeability 533 md.

In Figure 11 are shown the oil isoperms for a sandstone of identical properties but calculated on the assumption that the $1/P_c^2$—saturation plot is a right triangle. The equation for oil relative permeability then becomes, by considering the geometrical relationships shown in Figure 2,

$$k_{ro} = \frac{(S_o)^3}{(1 - S_{wi})^4} \quad (2\,S_w + S_o - 2S_{wi}), \qquad (33)$$

where $S_o = S_L - S_w$ = fractional oil saturation.

It is observed that the difference in the isoperms calculated from Equations (25) and (33) is not large.

A striking feature of both Figures 9 and 11 is the fact that the relative permeability to oil at a constant oil saturation may be increased by an order of magnitude if the water saturation is increased at the expense of gas saturation. Thus in Figure 9 the relative permeability to oil at an oil saturation of 14% increases from 0.1% to 1% as the water saturation increases from 30% to 80% (gas decreased from 56% to 6%). Permeability increases of this type decrease as the oil saturation increases although even at relatively high oil saturations increases in relative permeability of 50% or more are possible. The explanation of this phenomenon lies not in any variation of the impedance or tortuosity factor with changing oil, water and gas saturations, but in the change in the average size of the pores occupied by oil as the water saturation is increased. The oil is pushed into progressively larger pore sizes with increase in water saturation; the resistance to flow of oil correspondingly decreases.

In Figure 12 the $1/P_c^2$—saturation plot is shown for a packing of spheres of equal size. The plot tends to be rectangular rather than triangular and reflects the fact that there is only a small variation in the size of the pores in the packing. Figure 13 shows the oil isoperms calculated from the $1/P_c^2$—saturation plot of Figure 12. Here the small variation in pore size is reflected in the almost constant oil relative permeabilities calculated.

Status of Fluid Flow Problem. The derivations given above seem to conform reasonably well to the results of experiments suitable for checking them. It is quite certain, however, that far too few experimental data exist to permit a thorough valuation of the models devised. A necessity then is for relevant experimental data to be obtained for (a) single-phase permeabilities, (b) two-phase relative permeabilities and (c) three-phase relative permeabilities. Of these three, studies along the lines of (a) and (c) are

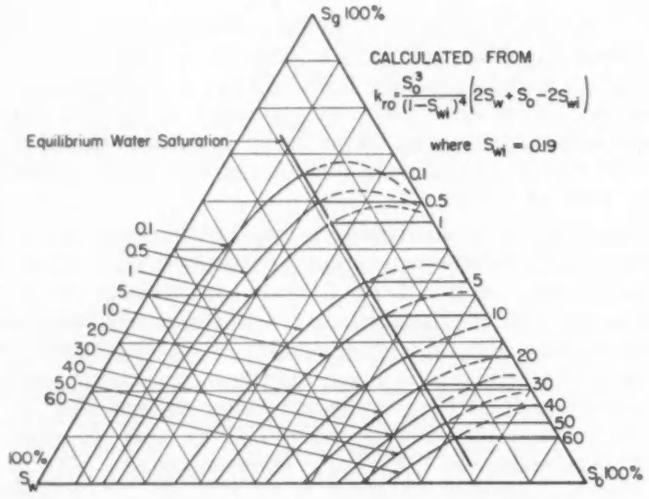

FIGURE 11—Oil isoperms for sandstone with identical properties.

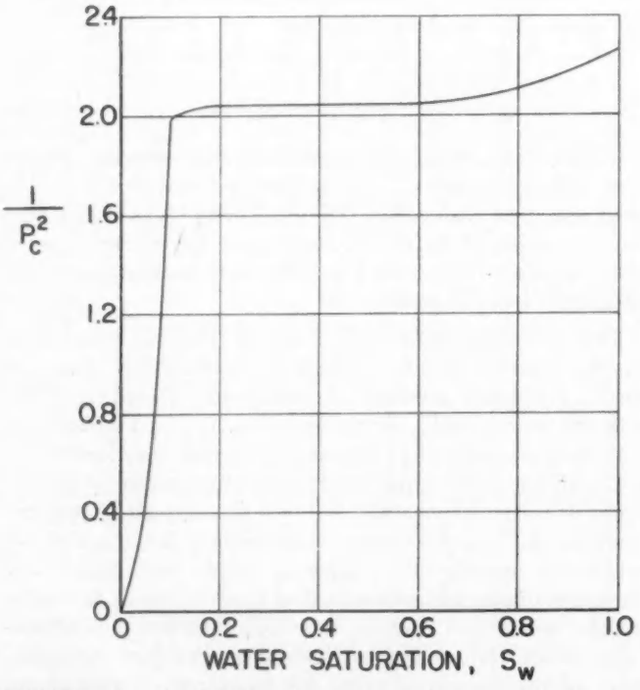

FIGURE 12—Plot of (capillary pressure)$^{-2}$ vs. saturation for unconsolidated spheres.

NOMENCLATURE

A = bulk area of porous medium
F = formation factor (electrical) at 100% saturation
F_e = formation factor at wetting phase saturation S_w
I = resistivity index of wetting phase = F_e/F
I_n = resistivity index of non-wetting phase
K = single phase permeability at 100% saturation
k = Kozeny-Carman constant $\cong 2.5(L_e/L)^2$
k_{rw} = relative permeability to wetting phase liquid
k_{ro} = relative permeability to non-wetting phase liquid
k_{rg} = relative permeability to non-wetting phase gas
k_o = hydraulic shape factor $\cong 2.5$
L = actual length of porous medium
L_e = apparent length of porous medium; or actual length of capillary tube
$(L_e)_w$ = apparent length of that part saturated by wetting phase liquid
$(L_e)_o$ = apparent length of that part saturated by non-wetting phase liquid
$(L_e)_g$ = apparent length of that part saturated by non-wetting phase gas
m = mean hydraulic radius
n = geometrical factor in capillary-probability model
P = pressure gradient = $\Delta P/L$
ΔP = pressure differential
P_c = capillary pressure
Q = quantity of fluid flowing/unit time
R = arbitrary radius, electrical resistance of fluid contained in unit length of model unit cross-sectional area
R_o = electrical resistivity of conducting fluid
r = radius of capillary tube
$\bar{r}$ = radius of an equivalent tube in capillary-probability model; average radius as defined in Reference (10)
S = surface area per unit bulk volume; saturation as a fraction of pore volume
S_m = minimum non- wetting phase staturation for mobility
S_L = fractional total liquid saturation = S_w+S_o
S_o = fractional non-wetting phase liquid saturation
S_w = fractional wetting phase liquid saturation
S_{wi} = fractional immobile ("irreducible") wetting phase saturation
S_w^* = effective wetting phase saturation = $(S_w—S_{wi})/(1—S_{wi})$
S_o^* = effective non-wetting phase saturation = $(S_o)/(1—S_{wi})$
u = macroscopic or approach velocity
u_e = average velocity in pores of porous medium or actual average in a capillary tube
$\alpha(r)$ = distribution function governing capillary radii, i.e., $\alpha(r)dr$ capillaries have radii between r and $r+dr$
β = geometrical factor in capillary-probability model
γ = interfacial tension
ϕ = fractional porosity
ϕ^* = effective porosity = $\phi(1—S_{wi})$
θ = contact angle liquid-solid
μ = viscosity

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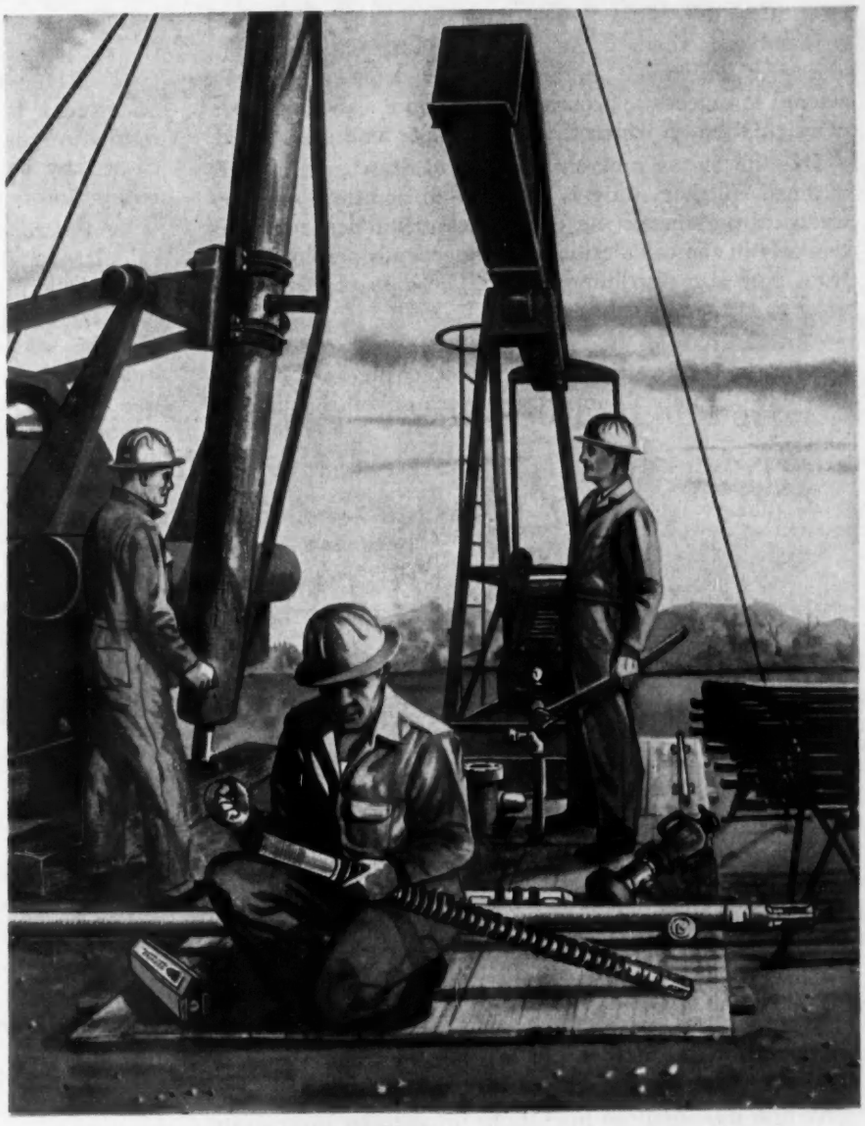

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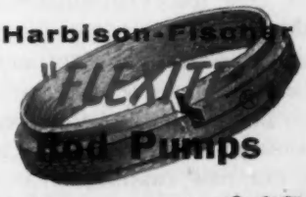

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most urgently required. The data pertaining to (b) are reasonably adequate if the excellent results obtained from Corey's approximate method of calculation can be considered to reflect the accuracy of the more elaborate mode of calculation on which the approximate method is based.

In spite of the inherent theoretical drawbacks already outlined, further study is required to ascertain whether electrical parameters are of significant practical use, particularly in the calculation of homogeneous permeabilities from pore size distribution data. The data of Faris et al seem to suggest that they are.

Further study of the resistivity index—saturation relationship both of wetting and nonwetting phases is of considerable theoretical importance because of the light it

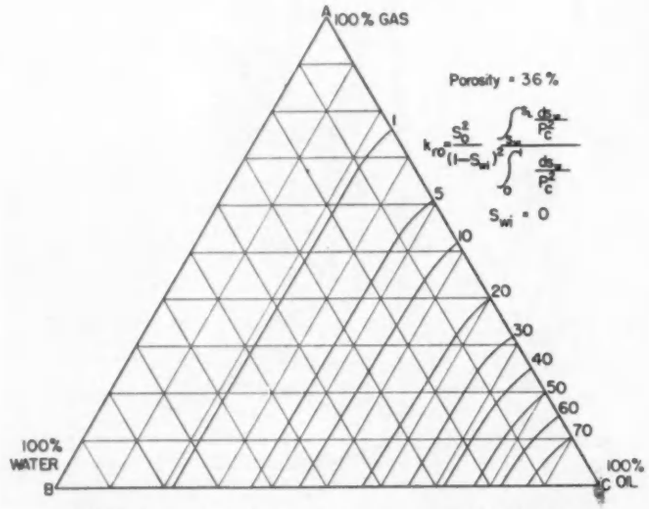


FIGURE 13—Oil isoperms for unconsolidated spheres.

can shed on the relationship between the distribution of pore sizes and the impedance or tortuosity factor.

Within the admitted limitations imposed by inadequate experimental data, can any conclusion be drawn? There seem to be several. The first is that the original Kozeny-Carman theory is generally inadequate as a means of expressing the fluid flow characteristics of porous media. The original theory is reliable only if all pores are of identical size. For a small range of pore sizes such as often characterizes unconsolidated porous media, the theory still is of practical service if errors of about $\mp 10\%$ can be tolerated. For consolidated porous media with uniform pore sizes, the theory is probably also applicable within about the same limits of error if the Kozeny-Carman constant is written as $2.5\ F^2\phi^2$ and the value of F is experimentally measured. Carman[2] has reviewed the evidence on which this conclusion is based. The advantage of employing the Kozeny-Carman equation in cases where it is applicable is its ability to give envelope surface areas, i.e., the surface area of the stationary film of liquid which laminar flow theory postulates as existing at fluid-solid contacts.

When pore sizes are not uniform, account must be taken of the effects of their variation. It was shown that this can be done either by Wyllie and Spangler's so-called generalization of the Kozeny-Carman theory or by the use of our new capillary tube—probability model. The relationship between the expressions involving pore size distribution parameters and the original Kozeny-Carman equation is tenuous. The principal link lies in the retention of the tortuosity term introduced by Carman. This term, however, seems ill-named. Use of the term impedance factor is preferred. Tortuosity does not appear primarily to reflect sinuosity but rather the restraints on flow caused by variations in the area available to the fluid within and between pores.

By the model it was shown that impedance may be calculated statistically and that the main factor it represents is the probability of pore interconnection. Available data on two-phase relative permeabilities certainly suggest that this simple view is basically correct. Other factors may be introduced at the expense of complicating the model. The two chosen were called β and n. It is reasonable that the factor β, a pore shape term, is not dependent upon saturation. The factor n, which in the prototype of the model corresponds roughly to the probability of a pore connecting with more than one other, may well be a function of saturation although not a sensitive one. Departures from linearity of the plot of $(L_e)_{1.0}/(L_e)_s$ against saturation at low values of saturation reported by Burdine[16] suggest that n is constant except when the saturation is small. The factor n is an interesting consequence of the new model since it leads to the phenomenon which Scheidegger[3] called dispersion. The authors have applied it to the problem of miscible displacement with some success.

Application of the model to the flow of electricity in porous media leads to an expression for the maximum possible formation factor at any porosity, i.e., to $F = 1/\phi^2$. This result is in reasonable agreement with experimental data.

A similar application to the calculation of the resistivity index—saturation relationship leads to $I = S_w^{-2}$. Experimental measurements of this relationship are discussed in the literature.[8] It can be said that for unconsolidated sands $I = S_w^{-2}$ and that this is true also for many consolidated sands. However, values for the exponent which are less than 2.0 have been observed. It can be claimed that such values represent experimental error either because the specimens chosen were heterogeneous or because they contained conducting particles. But this is not certain; further experimental data are required.

More inexplicable by far are the well authenticated data which show for synthetic porous media (alundum, pyrex glass) that $I = S_w^{-2.5}$. Here a factor other than simple impedance is operative. Whether it is the result of variations in pore shape with pore size resulting from the mode of manufacture of the synthetic media is uncertain. An elucidation of this point and, more generally, of the reasons for the frequently anomalous behavior of synthetic porous media would be particularly valuable.

This discussion has neglected all consideration of flow behavior in porous media where saturations change by imbibition; also, concomitant hysteresis effects were ignored. An understanding of these phenomena is vital to a complete grasp of the nature of fluid flow in porous media.

REFERENCES CONTINUED

[16] Purrcel, W. R., *Trans. AIME*, **186**, 39 (1940).
[19] Corey, A. T., and Rathjens, C. H., *J. Pet. Tech.* 69 (December 1956).
[20] Corey, A. T., Rathjens, C. H. Henderson, J. H., and Wyllie, M. R. J., *J. Pet. Tech.* 63 (November 1956).
[21] Leverett, M. C., *Trans. AIME* 142, 151 (1941).

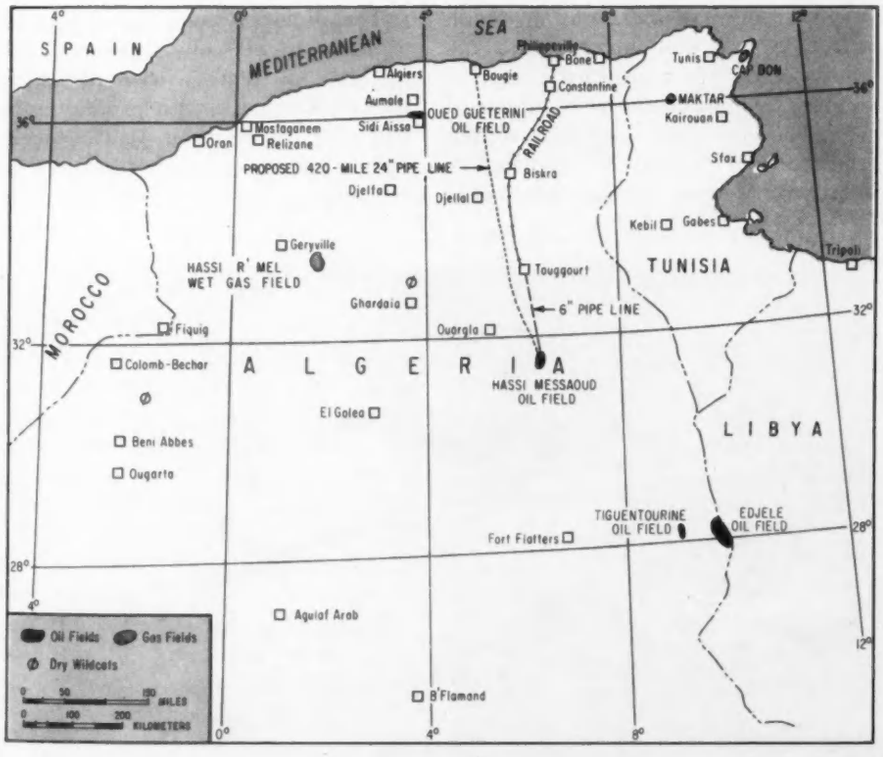
ACKNOWLEDGMENT

Presented at Conference on Theory of Fluid Flow in Porous Media Symposium Sept. 23, 1957, University of Oklahoma, Norman, Okla.

Two Sahara areas confirmed as major fields

• Hassi R'Mel wet gas field is estimated to have 150 million barrels of liquid petroleum reserves. It produces from over 150 feet of Ordovician sandstone around 7,000 feet. Seismic reflection indicated large uplift.

• Hassi Messaoud oil field is believed to have 800 million barrels of reserves already proved. It may yield billions of barrels when fully developed. A large and flat structure promises a huge field. A gently dipping dome was indicated by seismic refraction. Light oil comes from about 250 feet of Paleozoic sandstones lying below Triassic salt around 11,000 feet.



Algeria's Hassi Messaoud oil field is shown near the center of this map. It already has proved oil reserves of 800 million barrels. A six inch pipe line moves a little of its oil to Touggourt, and the oil goes then by rail to Philippeville on the Mediterranean Sea.

Plans have been announced for a 420 mile, 24 inch pipe line from Hassi Messaoud to Bougie, on the Mediterranean.

Another important new producing area is the Hassi R'Mel wet gas field, northwest of the center of this map. It has estimated proved reserves of 150 million barrels of liquid petroleum, along with large gas reserves. It may also produce crude oil eventually.

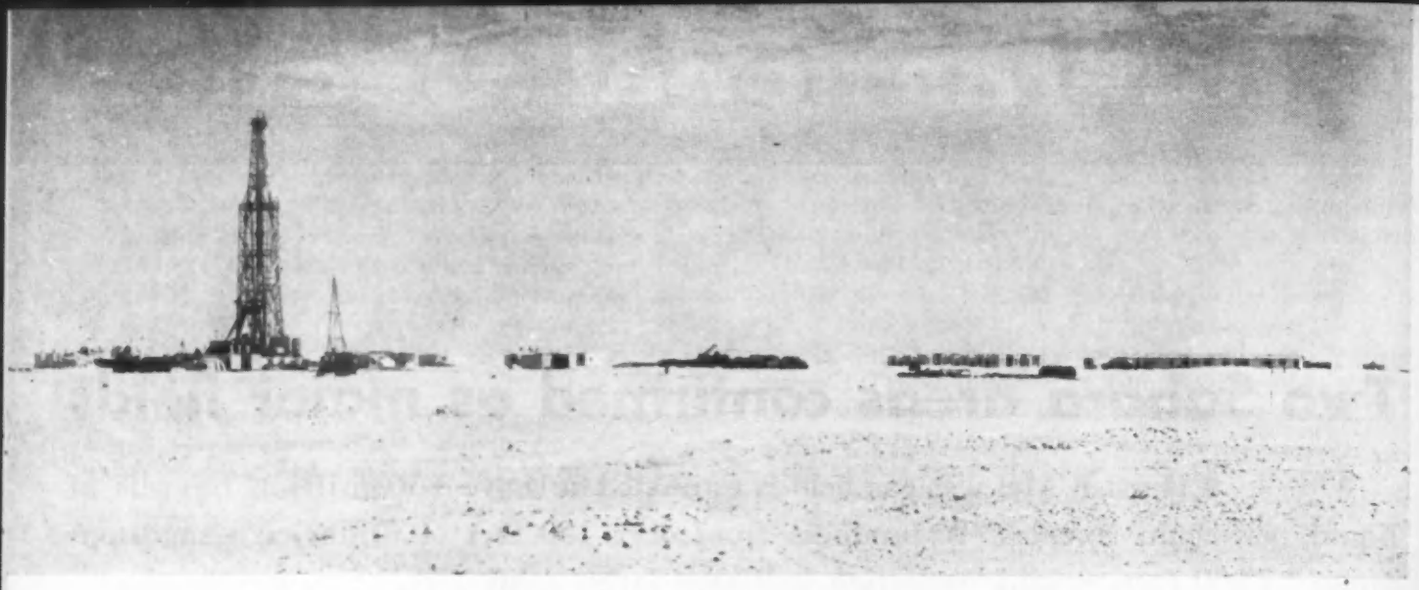
MAJOR IMPORTANCE is attached to two discoveries in the French Sahara. They were made by SN REPAL (Société Nationale de Recherches et d'Exploitation des Pétroles en Algérie), a company owned by the French government.

- A wet gas field has been opened at Hassi R'Mel, between Laghouat and Ghardaia, 250 miles due south of Algiers.
- Oil production has been established at Hassi Messaoud, near Ouargla, 400 miles south-southeast of Algiers.

Hassi R'Mel field. The gas field discovery well, Hassi R'Mel-1, was located on a large uplift, indicated by seismic reflections. Between 6,995 and 7,280 feet, the well drilled through 154 feet net thickness of gas-bearing sandstones, of lower Triassic and upper Ordovician age.

The potential of the well is 18 million cubic feet per day, with 200 pounds per square inch differential for a formation pressure of 4,400 psi.

The gas contains 200 grams of liquid per cubic meter (gas-oil ratio of 20,000 cubic feet per barrel). Since the gas reserve is estimated at 100 billion cubic meters (3500 billion cubic feet), the liquid content



Discovery rig and camp at Hassi Messaoud in the Sahara Desert.

The Sahara has developed into a large scale seismic frontier. See Page 126.

TABLE 1—Report on Hassi R'Mel (HR-1), Discovery Well

COUNTRY: Sahara.
PERMIT: Berriane.
COMPANY: SN REPAL.
OUTFIT: CFPA.
LOCATION: 15½ miles South of Tilghemt.
SPUD IN DATE: September 1956.
HOLE CONDITION: 7 Inch Casing to 7,005 feet. TD 7,465 feet. Plug back unknown. Might be 33 feet.

PRODUCTING FORMATION

Feet	Formation
6995—6985	**Triassic** Fine to medium sandstones 23% porosity 100 to 1000 md. Shale intercalations.
6985—7136 (T.D.)	**Ordovician** quartzitic sandstone with fractures and joints partly filled by Triassic shales. Mud losses. Gross thickness 427 feet.

PRODUCING CHARACTERISTICS

Reported: 1.400 m3/h gas over 14 metres.
30.000 m3/h gas over 4.2 metres with small draw down.
170 Grammes Gasoline per cubic meter.

Unofficial: 200.000 m3/hour wet gas (150 gr/m3)
Over 130 metres with 30 kgs drawdown.
BHP 306 kg/cm2 at 7050 feet.

GEOLOGICAL DATA

Feet	Formation
0—98	Senonian
66—262	Turonian
98—590	Cenomanian
590—2428	Continental intercalaire
2428—2821	Marine Lower Cretaceous
2821—4068	Upper Jurassic
4068—4774	Dogger
4774—5331	Upper Liassic
5331—5938	Lower Liassic
5938—7280	Triassic
7280—7464	(T.D.) Orodivcian

FORMATION AS A RESERVOIR

Feet	Formation
6995—7050(+)	Triassic Sandstone 23% 100 to 1,000 md.
7050—7182(+)	Fine to medium sandstone with clay intercalation.
7182(+)—7280	Bituminous sandstone with thick layer 33 feet gas bearing around 7,087 feet.
—7280	Fractured Ordovician fractures and joints partly filled with Triassic shales. Mud losses.
—7465	Total depth.

PRODUCTION TESTS

Feet	Results
1. 5237—5305	Brackish water BHP 125 kg/cm2.
2. 6995—7050	Gas
3. 7005—7050	1,400 m3/h gas Static BHP 306 GOR 1/5,000 m3/m3.
4. 6982—6996	30.000 gas m3/hour with small drawdown.

5. Unofficial 7,005 to 7,431 (?) 20.0000 m3/hour gas. Since TD 7,465 feet, it was wondered if the bottom hole was water bearing and plugged, since the gross thickness is reported as 427 feet, whereas casing shoe to T.D. is 459 feet.

amounts to 25 million cubic meters (150 million barrels).

Details on the Hassi R'Mel discovery well are presented in Table 1.

Plans are contemplated for laying two feeder lines—one to Algiers and one to Oran—as a contribution towards northern Algeria future industrial development. The economic interest of this project has not yet, however, been worked out in detail.

REPAL is now investigating the flanks of the structure in the hope of finding oil. The discovery of oil would be of more economic significance than the transport of gas by pipe line to northern Algeria. The gas lines would fill a possible short term consumption of 20 billion cubic feet yearly.

Hassi Messaoud field. So far, Hassi Messaoud is the most interesting discovery in the Sahara. Reserves there have been estimated at being in the billion barrels range. The most conservative estimate of recoverable oil is 800 million barrels.

The discovery well MD-1 brought to light an oil column of over 100 meters (330 feet) with a net thickness of 250 feet and a production of 150 tons (more than 1,125 barrels) daily although somewhat reduced by skin effect. The oil came from Pale-

Topographically, the Hassi Messaoud region shows a slightly eroded plateau covered by the first dunes at the rim of the Great Eastern Erg. Any structural features that might exist in the area are now hidden under the flat-lying, continental Mio-Pliocene formations of the plateau. First oil produced at Hassi Messaoud is shown in ditch at right.

ozoic sandstones at 10,922-11,377 feet, encountered below a thick rock salt body of probable upper Triassic age.

Well OM-1, the follow-up to MD-1 was drilled by CFP(A), a company working in association with REPAL, five miles north of MD-1. Production of 400 tons (over 2,500 barrels) daily was established some 175 feet structurally higher.

At the same time REPAL itself was drilling well MD-2, located 7 miles west-southwest of MD-1, which established an oil production of 200 tons (1,250 barrels) per day. That well was structurally 150 feet lower than MD-1. It indicated the proximity of a southwest flank on the structure.

Wells MD-3 and MD-4 have been completed 2½ miles northeast and northwest of the discovery well, with production potential of 600 to 800 tons (3,750 to 5,000 barrels) per day.

MD-5, situated 3½ miles southwest of MD-1, was drilling in the pay zone in February, 1958.

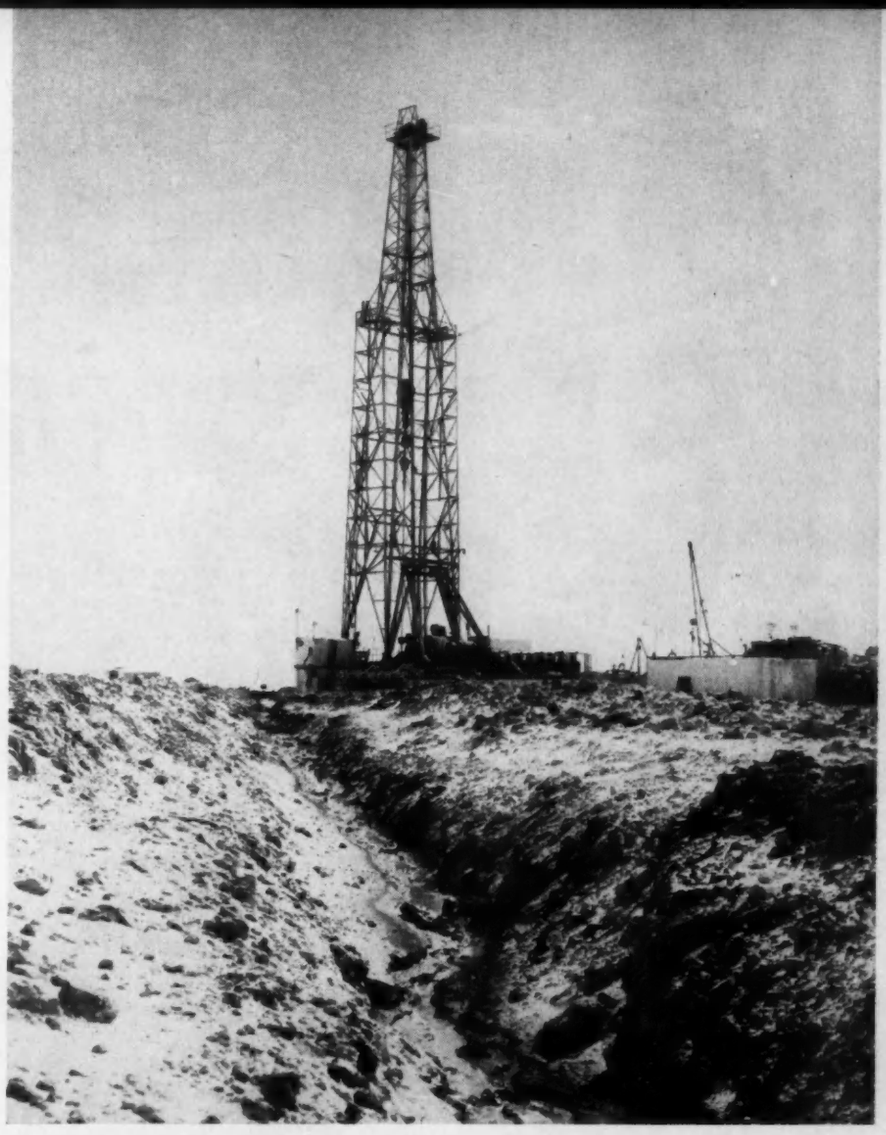
Size of structure. Hopes that this will be a huge field may be realized, since the structure is large and flat. The area already encompassed in February, 1958, by REPAL wells and two wells of their associates, Compagnie Francaise des Pétroles (OM-7 and OM-81), is 235 square kilometers (90 square miles, or 57,600 acres).

Seismic evidence points to the possibility of a further increase in the productive area.

Present program. At the end of March, 1958, REPAL was due to have spudded in four wells, MD-6, MD-7, MD-8, and MD-9, at distances of 7 to 10 miles from MD-1, along a wide arc on the south flank of the structure. Those wells were located so as to delineate the oil-water contact.

REPAL's associates, C.F.P., planned three locations on the same structure, but 15 to 20 miles north of MD-1. Those locations, although structurally high, might find the sandstone more argillaceous or truncated by erosion. The stakes are high, in connection with the wells, since the area encompassed by the new locations exceeds 1,000 square kilometres (400 square miles or 256,000 acres).

Companies and concessions. SN REPAL (Société Nationale de



The Hassi Messaoud field discovery well is shown here. It was drilled with American-made rig and mast owned by "SN REPAL," the French government company. Drilled to 14,508 feet, the discovery well, "MD-1", penetrated 459 feet of oil-saturated Permo-Triassic sandstone below 10,922 feet. It was completed for 931 barrels of 35 gravity oil daily on a 21/64-inch choke.

The burning torch at Hassi Messaoud well "MD-1" during testing. In the background is the upper part of the U.S.-made mast used in drilling the well.

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Recherches et d'Exploitation des Pétroles en Algérie) was created in 1946 by the French government. Of it present capital of 18 billion francs ($50 million) 50 percent is owned by the French Algerian administration; 48.45 percent by the Bureau de Recherches de Pétrole (section of the French administration in Paris concerned with crude oil prospecting) and 1.55 percent by the public through the oil investment company COFIREP. SN REPAL's general manager is Armand Colot; its assistant general manager, Fernand Leca; and exploration manager, Igor Ortynski.

SN REPAL conducts Saharan operations as a joint financial venture with CFP(A): Compagnie Francaise des Pétroles d'Algérie, a Company partly owned by the French government. The expenses and profits are equally divided. Technically, each company operates separately on their imbricated permits, which cover a total of 248,000 square kilometers (95,600 square miles).

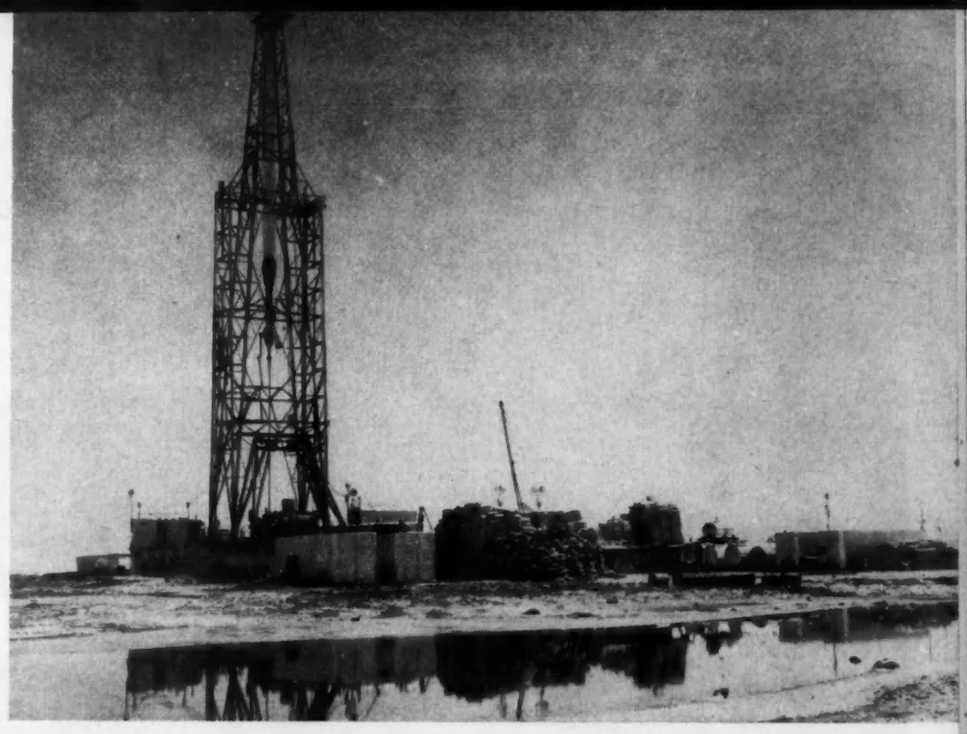
REPAL and C.F.P. have now reached the end of the first five years period of their exploration, and have surrendered to the government 50 percent of the acreage of each of their permits.

Several companies (including C.F.P. itself), some of which have been formed especially for the purpose, have made bids for these surrendered acreages. It is expected that the French government will make known its decision shortly.

General outline of geology of area. Topographically, the Hassi Messaoud region shows a slightly eroded plateau covered by the first dunes at the rim of the Great Eastern Erg. Any structural features that might exist in the area are now hidden under the flat-lying, continental Mio-Pliocene formations of the plateau.

The location of the exploration well Hassi Messaoud 1 (Md-1) was selected on seismic refraction evidence, which revealed the presence at depth of a gently dipping dome.

Underneath the red beds of the Mio-Pliocene, the bit penetrated rather thick, laguno-marine deposits of the Upper Cretaceous, then the Lower Cretaceous and a sub-continental, sand-clay sequence of the Jurassic. Still deeper, below a lagoonal



Close-up view of drilling rig and mast at Hassi Messaoud discovery well, MD-1.

Liassic, the bit drilled its way through a thick rock salt body which very likely pertains to the Upper Triassic.

Siliceous and dolomitic, azoic sandstones of the Paleozoic occur at a depth of 10,922 feet. On cuttings they showed a good fluorescence, and interesting quantities of light oil were recovered during drill stem tests.

REPAL'S operations adapted to desert conditions. Due to the rigorous climate and the isolation of the site, the installation is heavier than usual. The air conditioned camp requires 100 to 125 kilowatts power plants. Water is fortunately abundant at a depth of 300 feet. But food has to be transported by truck or flown from Algiers, 400 miles away. One weekly DC-3 load per drilling rig (2.2 tons) is required for fresh or frozen food, personnel and urgent supplies.

The liaison with headquarters in Algiers is provided by 300 watts radio stations operating on 5,000 to 10,000 kilocycles frequency (60 to 30 meters wave length) and tied in Algiers with the government telephone system.

Practically all the personnel is French.

Drilling and mud programs. The discovery well was drilled with a rig made by a U. S. company equipped with a mast made by the same company and belonging to REPAL. This well was stopped at a depth of 11,377 feet. The following casing strings were set:

Casing (Inches)	Approximate Depth	
	Meters	Feet
13¾	208.7	685
9⅝	2,290.0	7,513
7	3,358.0	11,016

During drilling flows of fresh water were observed between 1,110 and 2,300 meters (2,670 and 7,600 feet) in the sandy series of the Lower Cretaceous (Albian) which constitutes over the whole of the Sahara an excellent and often much-needed source of fresh water. The potential of this reservoir of fresh water at Hassi Messaoud is 10,000 tons per day.

At 2,626 meters (8,700 feet) in the Upper Triassic (Keuper) a yield of salt saturated water with an abnormal pressure of 500 kg/cm² (7,000 psi) necessitated the addition of barites to the mud in order to make possible futher drilling.

The mud was saturated with salt, since the Upper Triassic included about 2,297 feet thickness of massive salt.

MD-1's production was reduced by skin effect, and the pay zone of subsequent wells was drilled with low solids content muds: a fresh low pH mud, with CMC for viscosity water loss and barites to raise the specific

Drilling rig and air-conditioned camp at Well "MD-3" in Hassi Messaoud field. The rig is one made by a U. S. company.

gravity to 1.6. This mud was successful in reducing skin effect to low values.

Oil base mud was tried at MD-3. The well gave a potential of 600 tons (3,750 barrels) per day, with no apparent skin effect. Since the mud was found easy to handle and to control, REPAL contemplates extending the use of oil base mud to more of their future wells.

Production. A daily production of 3,000 bbls per well is expected, despite the low permeability, thanks to the combination of a high formation pressure (6,800 psi at 11,000 feet) and a low oil viscosity of 0.6 cps in the formation (the product thickness by permeability is 2,000 feet by millidarcys).

The porosity in MD-1 ranges from 4 to 14 percent and averages 8.6 percent. REPAL estimates that despite this low permeability, the connate water is only 10 percent, which supposes a rather deep oil/water contact. The oil recovery factor could also be increased by the low oil viscosity of 0.6 cps at reservior conditions.

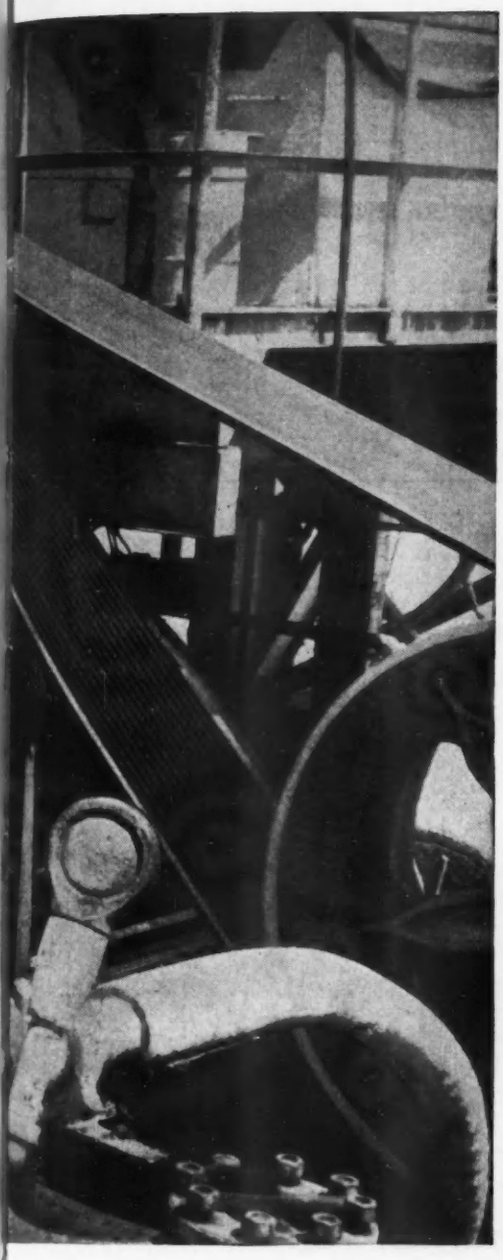
Reserves Large. It is estimated that 13,000 barrels of oil per acre will be recoverable (1 million tons per square mile). Hence, the proved recoverable oil is 100 million tons (832,000,000 barrels). But the probable recoverable oil is 500 million tons (4,160,000,000 barrels) or more.

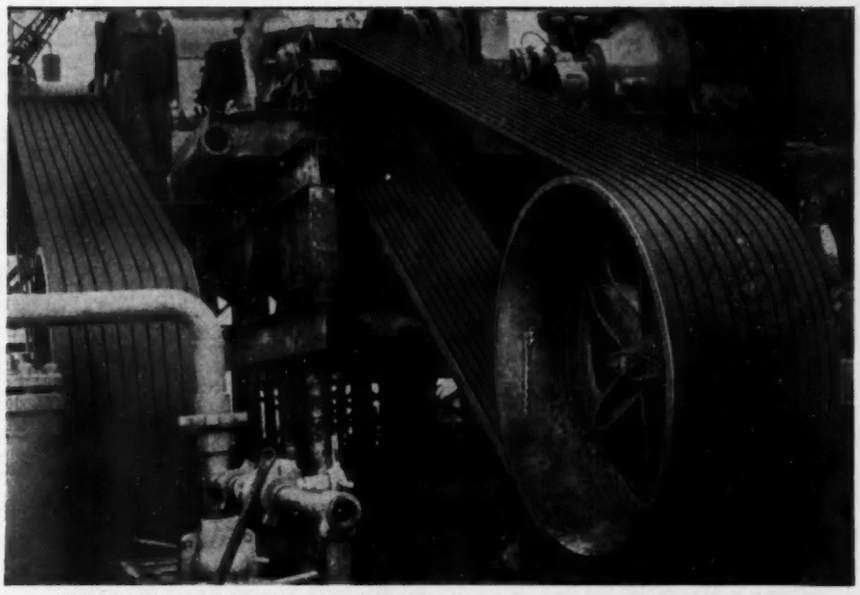
Development. A small-scale "crash program" has been launched for political as well as economic reasons. Eight heavy rigs will be placed in the area to enable 20 wells to be drilled per year. A 6 inch pipe line was completed early in 1958 between Hassi Messaoud and the oasis of Toggourt 160 kilometers (100 miles) north. It has a capacity of 2,000 tons (13,300 barrels) per day.

From Toggourt, the crude will be moved by railway tank cars at a rate of 1,200 tons (8,000 barrels) per day, to Philippeville, half way between Algiers and Tunis, on the North African coast. Only token amounts are at present being transported by rail to the Mediterranean coast.

The long term program includes a big pipe line to the coast and a production by 1960 of 6 million tons per year (40 million barrels annually, or about 110,000 barrels daily) from Hassi Messaoud alone. A long term program for a 24-inch pipe line, 420 miles long, to Bougie, east of Algiers, has been announced. These plans are not yet finalized.

The pipe line plans will probably not be finalized before futher information about the reserves and production rates become available.





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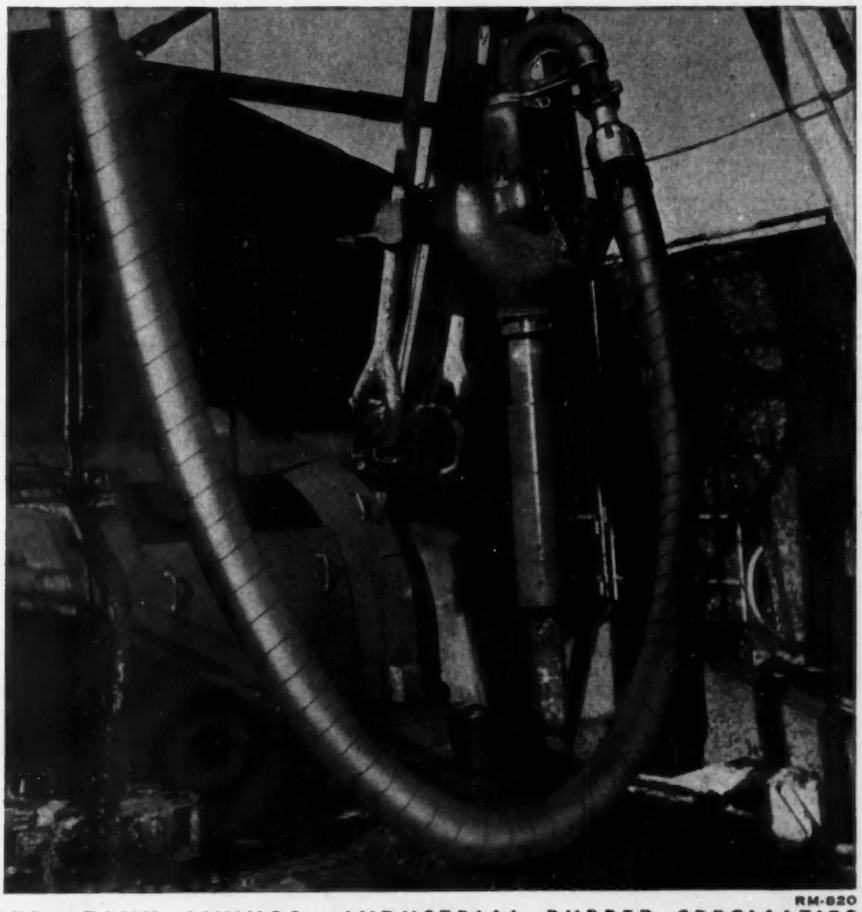

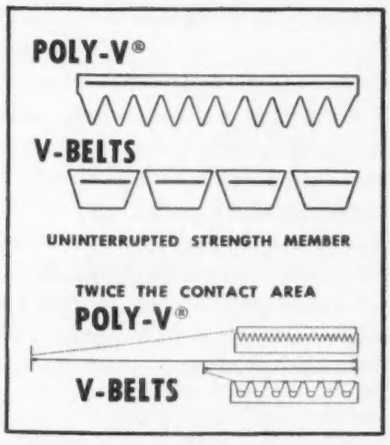

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DRILLING HINTS

These How-To-Do-It Ideas Can Save You Money

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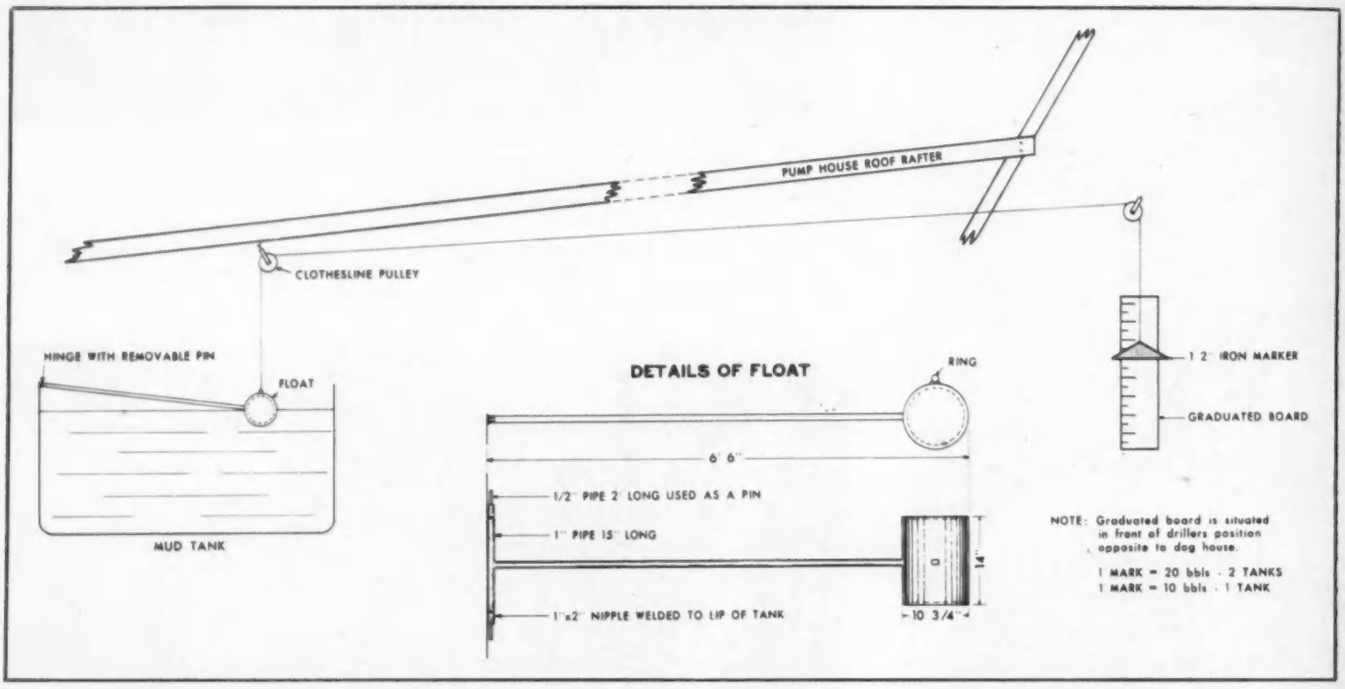

PUMP HOUSE ROOF RAFTER
CLOTHESLINE PULLEY
HINGE WITH REMOVABLE PIN
FLOAT
MUD TANK
DETAILS OF FLOAT
RING
6' 6"
1/2" PIPE 2" LONG USED AS A PIN
1" PIPE 15" LONG
1"x2" NIPPLE WELDED TO LIP OF TANK
10 3/4"
14"
1 2" IRON MARKER
GRADUATED BOARD
NOTE: Graduated board is situated in front of drillers position opposite to dog house.
1 MARK = 20 bbls - 2 TANKS
1 MARK = 10 bbls - 1 TANK

Construct Mud Level Gage Float From Cylindrical Tank

Here is a new mud level gage designed to give accurate readings. The old type block float was not satisfactory due to currents in the mud tank causing it to drift. This resulted in inaccurate reading at the graduated board. Swirling action of the mud often wound up the gage wire and caused it to break.

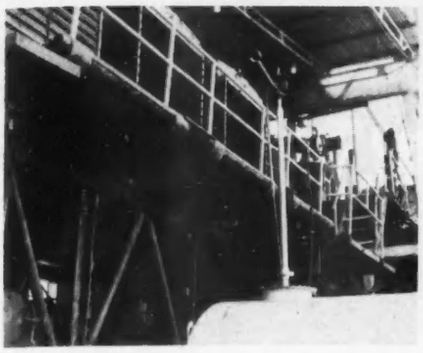
This new float is constructed of a thin walled 10¾-inch diameter cylindrical tank about 14 inches long. A ring for attaching the gage wire is welded to the top of the float. A 6-foot 6-inch float rod is welded to one side of the tank. The other end of the rod has a 15-inch piece of 1-inch diameter pipe welded at right angles to form part of a hinge. The hinge is completed by welding two 1-inch lengths of the 1-inch diameter pipe to the lip of the mud tanks, 15 inches apart. The piece of pipe on the float rod fits between them and a pin can be passed through the pipes to form the hinge. The pin is ½-inch material, pipe or bar.

The gaging line is secured to the top of the float and run over pulleys to the driller's station. At the driller's station it is connected to a 2-inch iron marker which acts as an indicator on the graduated board. This enables the driller to know at all times the exact level of the mud. As the float in the mud tanks goes down, the marker on the graduated board goes up; as the tanks fill up the marker will go down. The float is not affected by mud currents.

Provide Access to Pump With Pipe That Elevates

The machinery of a rig must have lubrication to operate efficiently. Usually the storage of this lubrication is on the ground level, and it is necessary for someone to carry the oil to the various units where it is used. A simple addition as shown in the photo can save many steps and a great deal of time for the crewmen.

The pump is usually mounted on top of the oil reservoir tank. By mounting the pump on a short piece of pipe and elevating it to a sufficient height, it can be easily reached from the engine platform of the rig. The



necessity for carrying the oil from ground level to the engine platform is removed.

Instead of the usual connections from the hand pump, a few feet of rubber hose will enable the crewman to control the oil after it leaves the pump. He can save the walk from the floor to the lube tank and back, and there will be much less time lost for this particular job. If the hose is of sufficient length, he can fill the engine oil tanks by putting the hose into the fill tube and using the hand pump to direct the oil to the engines.

The lube reservoir must be spotted on location so that it will place the pump in the most advantageous position near the engine platform and be easily reached from the floor level. The hose connection will also enable the crewmen to obtain oil when they are on the ground level. This will not only save the crewmen time, but enable him to work more safely around the rig by not spilling oil or lubricants on the walkways and floors, which is a well-known safety hazard.

How-To-Do-It Ideas Earn Money, too!

WORLD OIL editors want how-to-do-it ideas, so your favorite short cut or invention could put money in your pocket! Write down the substance of your latest ideas and send them in with a picture or drawing of the installation . . . if accepted, $10 for each idea will be yours. Send those money-making ideas today to Hints Editor, WORLD OIL, P. O. Box 2608, Houston 1, Texas.

Take Cuttings From Mud With Shopmade Desander

One of the major problems of drilling is the removing and settling of sands from the mud. On the Texas coast where floating sand problems are often encountered, a simple desander from a pump liner is finding wide usage.

The desander is very simply made by using a pump liner as the main body; on the top, a 2-inch connection is put on, and on the bottom, a 2½-inch swedge equipped with a gate valve, and a 2-inch connection on the side, which is welded so that the flow is directed around the cir-

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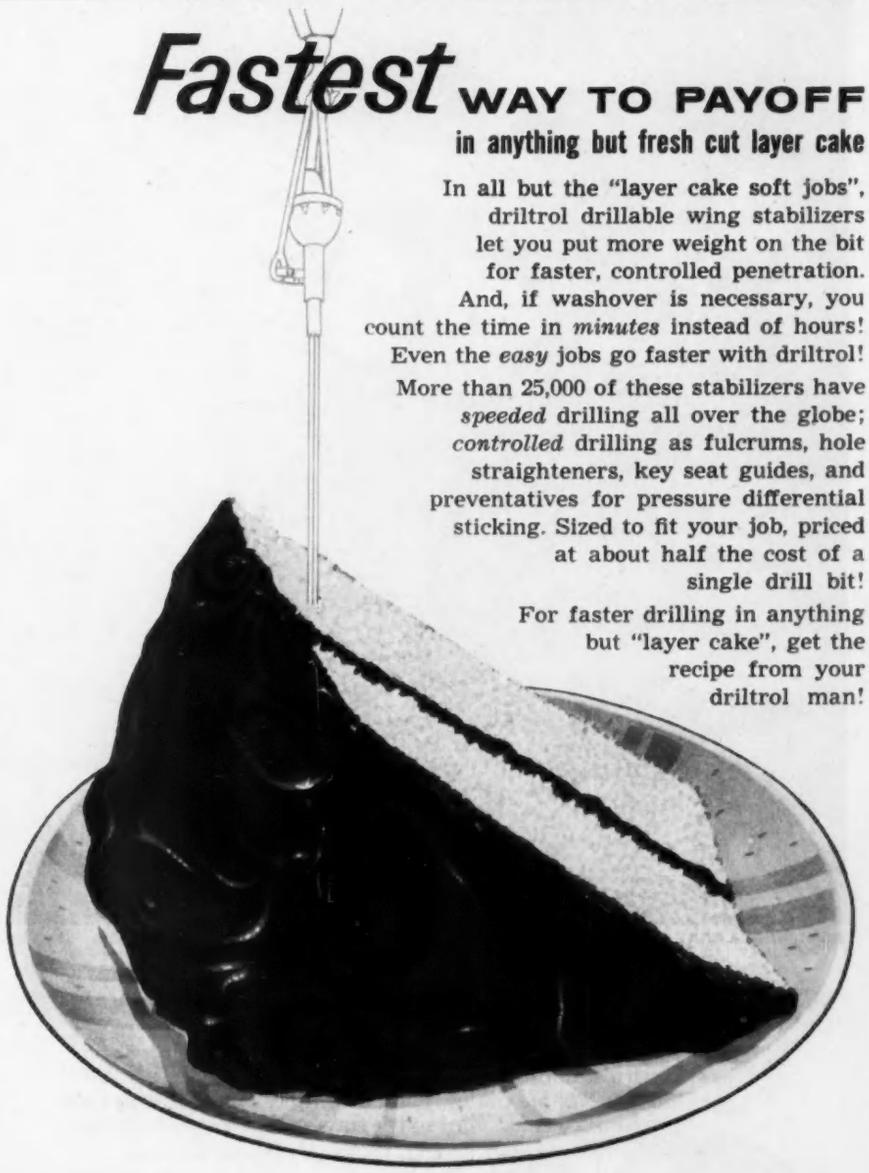

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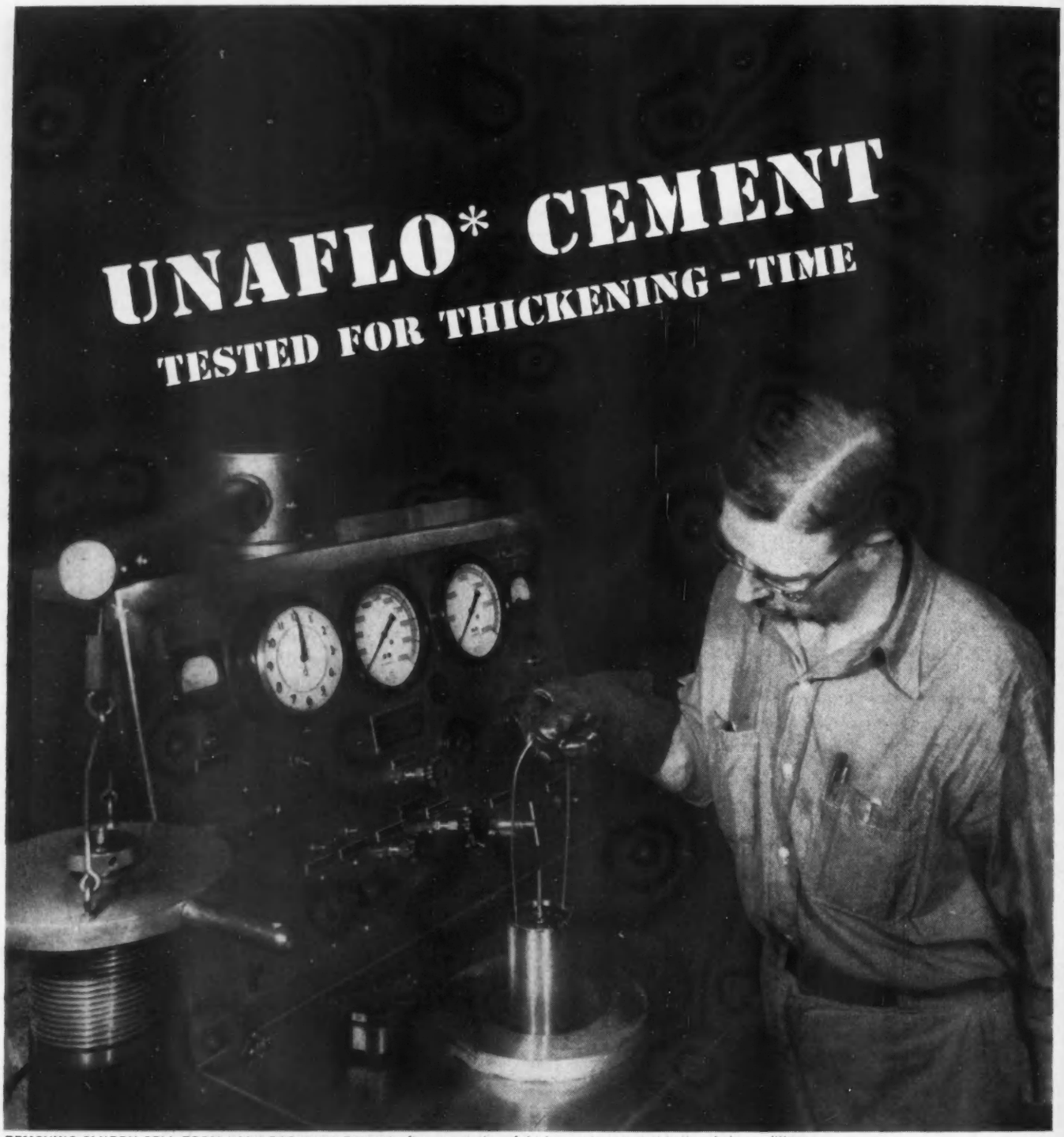

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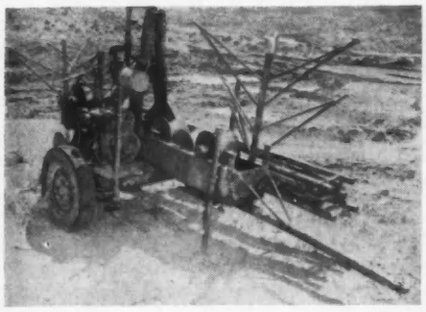
cumference of the inside of the pump liner. This 2-inch inlet in the side of the liner is equipped with a ceramic nozzle to eliminate wearing action. The top line is the return line to the suction pit.

In operation, the device is connected to the jet line running from the top of the mud tanks, and the mud is turned into the chamber. This causes a centrifugal washing action and the mud flows out the top of the chamber allowing the sand to be drawn off through the small outlet at the bottom.

The result is much cleaner mud, and less time is lost in the settling pits. Many operators report mud with 12 percent sand content reduced to zero in one pass.



Portable Pipe Straightener Can Be Towed on Truck

This portable pipe straightener can be towed behind a pickup truck. The straightener can be spotted easily at the end o. the pipe racks and the pipe "endoed" out through the straightener and back to the pipe rack. Temporary racks used in connection with the straightener are carried mounted on the trailer.

A regular two-wheel trailer is used, with the manufactured pipe straightener mounted so that the dollies are level with the pipe racks in the field. Temporary racks which hold the pipe while it is being straightened are made of light weight steel. They are constructed of 2-inch pipe with ¾-inch brace legs. The 2-inch pipe is slipped down over 1½-inch carrying pipes welded at the corners of the trailer. The stands shown mounted on the back of the trailer have adjusting holes so that they can be raised to the height of the drill pipe stand.

When a contractor has more than one rig, the portable straightener can be kept ready to roll.

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PRODUCTION HINTS

These How-To-Do-It Ideas Can Save You Money

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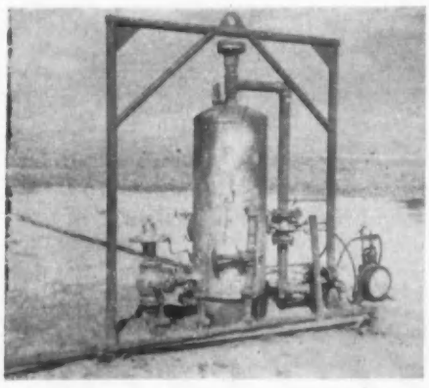
Underground Electric Service Insures Safety to Crews

Installation of underground electric service to electrified pumping wells eliminates the danger of overhead service lines, a potential hazard to pulling unit crews.

Although wires and lines to the unit are generally insulated, a falling guy line from a pulling unit will possibly strike and break through the insulation causing a serious accident. Service installed as shown in the picture on left give crews an adequate amount of working space when pulling rods or tubing.



Test New, Reworked Wells With Portable Separator

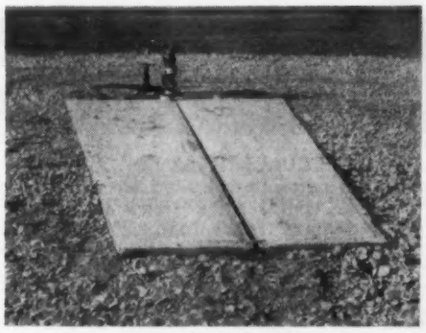
Portable separators can be used to test new and reworked flowing wells in areas where permanent test separators have not been installed. The portable separator, shown in the picture, was rigged up by one company to facilitate moving to various well sites. Skid-mounted on a metal plate base with vertical pipe framework and hook on the top horizontal frame, the unit can easily be moved by a lease truck with gin poles from one location to another.

When it is necessary to test a well, the unit can be spotted near the line to the burning pit. After the well has cleaned up, this line can be used for venting the gas produced.

If it should become necessary to work on the separator, production can be switched directly into the test tank. Valves in the riser and on the downstream side of the dump valve are closed and the by-pass valve, shown between the vertical riser and the tie-in from the dump valve, is opened. The gas line is tied into the top of the trap with a burst plate mounted on top of this riser for relief purposes. The orifice flange connection should be mounted on the vertical line to eliminate the surge from any entrained liquids in the gas stream. A portable recorder is used to measure the differential and static pressures.

Framework for the separator base mounting can be made from scrap metal plate which is welded to scrap pipe serving as skids. The vertical frame risers, horizontal section of the frame and the diagonal brace members can be made from scrap line pipe or tubing. These are welded together,

as shown, with triangular metal plates welded in each corner of the top section and to each side of the vertical risers at the base for increased structural strength.



Channel Sections Speed Anchoring of Pumping Unit

A variety of ideas are employed for anchoring the pumping unit, probably the most common of which is to embed a length of three- or four-inch pipe down the center of the pad, leaving just enough of the top surface exposed to permit later burning of holes into which the pumping unit anchor bolts are inserted, turned through 90 degrees and tightened down.

One Canadian operator prefers to use two lengths of channel iron, open sides facing each other, and held in place by temporary bars welded across the tops to hold them in place. Use of channel sections does away with the necessity of having a welder on hand when the anchor bolts are installed. In addition, by having the slot already open and extending the full length of the pad, there is no need for determining beforehand exactly where the bolts will be installed.

Sometimes it is desirable to shift a bolt, after the unit has been started up, to improve the tie-down; also there are occasions when a different size or different make of unit will be brought in to replace the initial installation and which would require shifting the anchor bolts to new positions.

As can be noted, use of the channels permits easy troweling of the cement to establish a gentle slope toward the center of the pad, allowing water, oil and grease to flow, or be flushed toward the channel and out to the rear of the unit.

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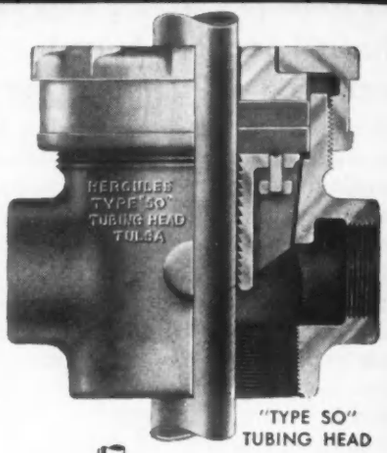
HERCULES "Type SO" Tubing Head is particularly suited for pumping due to compactness (only 12½" high). Stripper rubber can be used in body for running or wiping tubing. Also ideal for intermittently flowing wells.



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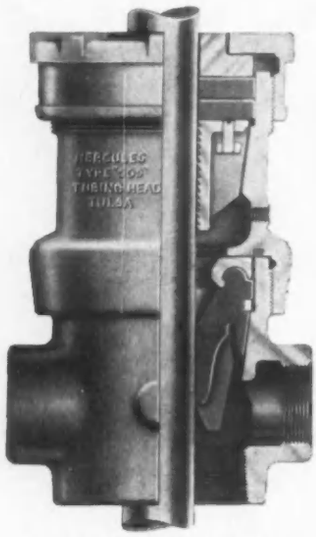

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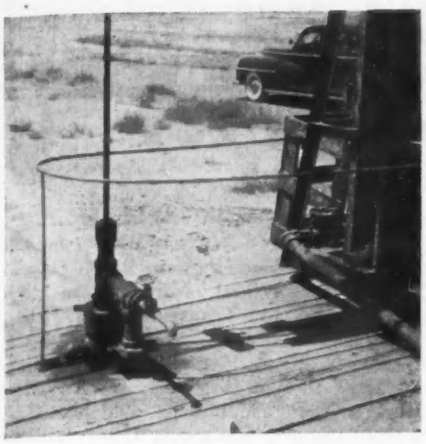
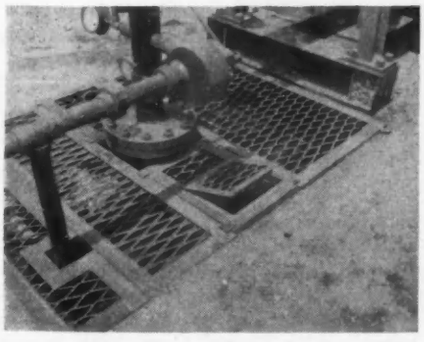


Build Pump Unit Guard Of Lightweight Steel

Lightweight reinforcing steel can be used to build a pumping unit guard for wellhead protection if sucker rod material or other heavy metal is not available. The guard pictured in this installation was made of lightweight steel and hooked directly to the sampson post frame. Sockets of ¾-inch pipe are used to hold the hooks bent into the ends of the guard.

The third leg, in this case, is attached in a vertical position and is prevented from wandering by setting it in a hole bored part way through the cellar floor plank. The guard surrounding the crank and rear portion of the pumping unit is constructed of one by six lumber.

Should this type of horsehead guard be used on a well equipped with a steel mesh cellar covering, the single leg could be held in place by inserting it in a socket of small diameter pipe welded to the decking.



Sectionalized Cellar Cover Simplifies Accessibility

Building the cellar cover in several sections, while entailing more work and materials at the outset, can save much time and effort during subsequent life of the well. One operator finds it advantageous to build the cover out of large mesh expanded metal and angle iron, the latter being placed with the angle looking downward and permitting it to rest on and be supported by the edges of the concrete cellar. This allows the pumper, who usually is working by himself, to lift out only that segment that gives him access to the section desired or, if necessary, to remove the entire cover but in easily-lifted pieces.

To facilitate access to a casing valve, or to permit running a vacuum truck suction hose into the cellar, a still smaller, hinged, opening was provided in one of the five principal sections.

Unlike two-inch planking which frequently is subjected to abuse and gradual deterioration and weathering, this all-metal type of cover will last the normal life of the well with little need for repair or replacing.

YOU CAN'T FOOL AN OIL WELL

Most any dairy cow gives a better account of herself if she's milked by a well acquainted and experienced hand. Old Bossie just seems to know the difference.

Oil wells are kinda the same way. Well kept records prove that almost any oil well seems to be a more profitable producer if equipped with a JENSEN JACK.

If 1958 finds you drilling new wells, putting old ones on the pump, or replacing producing equipment, you'd better not flange-up the deal until you've gotten all the facts and figures on JENSEN JACKS.

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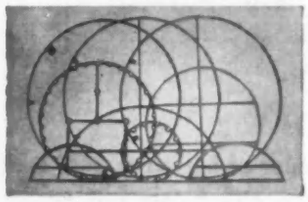

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What's Happening

among MEN in the INDUSTRY

Monterey Oil Company announced the appointment of **Ford M. Graham** as vice president and senior representative for the company in Louisiana and Mississippi. Graham as an independent oil and gas operator had served as consultant to Monterey and other producers for the past four years. He will direct exploration activities in the area from the company's offices in New Orleans.

Ford M. Graham

S. C. Stoneham has been appointed staff seismologist for **Standard Oil Company of California, Western Operations, Inc.** with headquarters at Oildale, Calif. In the newly-created post, Stoneham will have charge of developing new interpretation techniques and reviewing existing methods of seismic interpretation.

John R. Van Slyke has announced the opening of his office at 913 Central Building Wichita, Kansas, as consulting petroleum engineer, specializing in oil producing problems, property evaluations, reserve estimates, secondary recovery operations and unitization procedures. He has been employed by Barnett Oil Company for the past 6½ years.

Seaboard Oil Company of Texas has made many new personnel appointments. **G. W. Oliver** is now chief evaluation geologist, Production department, Houston. Other appointments are **D. P. Johnson**, division exploration superintendent. Oklahoma division, Pasotex Petroleum Company, Oklahoma City; **V. E. Tims**, division development geologist, Eastern division, Production department, Houston; **C. R. Hensch**, division exploration superintendent, Northern division, Exploration department, Dallas; **E. C. Masdon, Jr.**, assistant to chief development geologist, Production department, Corpus Christi, Texas; **Clarence Lohman, Jr.**, district geologist, Offshore district, Southern division, Exploration department, Houston; **J. G. Joyce**, district geologist, San Antonio district, Southern division, Exploration department, San Antonio, Texas; **W. A. Marshall**, district geologist, San Angelo district, Northern division, Exploration department, San Angelo, Texas; **N. J. Rabensburg, Jr.**, district geologist, Ozona district, Western division, Exploration department, Midland, Texas; **C. E. Edwards**, division geophysicist, Southern division, Houston; **B. M. Ganek**, division geophysicist, Northwestern division, Amarillo, Texas; **W. R. O'Brien**, division geophysicist, Northern division, Dallas; **N. R. Park**, division geophysicist, Western division, Midland; **K. R. Gilleland**, division geophysicist, Oklahoma division, Pasotex, Oklahoma City; **William McBee, Jr.**, division staff geologist, Northwestern division, Amarillo; **R. H. Shepard**, division staff geologist, Northern division, Dallas; and **D. C. Cedarleaf**, division staff geologist, Oklahoma division, Pasotex, Oklahoma City.

The Atlantic Refining Company has announced the appointment of **Edgar Kraus** as assistant general manager of the Domestic Crude Oil production department. He has served as manager of the Domestic Producing Exploration division since 1952. Kraus will move up to succeed **James N. Mendenhall** as general manager upon the latter's retirement within the next several months. **William B. Moore**, formerly manager of the company's South Louisiana Production region, has been named to succeed Kraus as manager of the Exploration division. **Louis F. Davis** has been appointed to the new position of regional division manager, heading up the company's six producing regional divisions. He was formerly manager of the Oklahoma-Kansas region.

Sinclair Oil Corporation announced the following promotion. **James E. Dyer**, since 1954 president of Sinclair Refining Company, was elected vice chairman of the board of directors. Dyer has been a vice president of the parent company since 1951, and a director since 1952.

James E. Dyer

Petrol-Structors Ltd., consulting engineers with offices in Calgary, Alberta, announced the appointment of **R. Franklin Parker** as executive vice president, general manager and director. Parker was most recently with Bechtel Corporation in San Francisco.

C. F. Dohm was elected president and director of **Pan American International Oil Co.** Pan American International, a newly formed subsidiary of Pan American Petroleum, has been organized to carry out

oil exploration and development operations in the Eastern Hemisphere. Its principal offices will be located in New York City with at least one branch office to be established in Europe. Dohm was formerly president and director of Conorada Petroleum Corp., a subsidiary of Continental Oil Co., The Ohio Oil Co. and Amerada Petroleum Corp. He has had more than 20 years' experience in oil exploration and development activities abroad.

Seaboard Oil Company announced the appointment of **H. C. McCarver** as manager of exploration replacing **R. A. Stehr.** Stehr will continue to act as a special adviser to the Exploration department.

James Armstrong Richardson was appointed director of **Hudson's Bay Oil and Gas Company Limited.** Richardson is also vice president of James Richardson & Sons, Ltd., Winnipeg.

Paul R. Waddle, Southern division reservoir engineer for Carter Oil Co. in Shreveport, La., has resigned and opened offices as a consulting petroleum engineer. He will specialize in reservoir performance studies, oil and gas reserves calculation, and evaluation of oil and gas properties. Waddle had been with Carter for 12 years.

Paul R. Waddle

Tom Gaines has been appointed assistant manager of **Texas Petroleum Company's** Colombian Producing division, at Bogota. Gaines was formerly chief petroleum engineer of Texaco Exploration Company, Calgary, Canada. He has been succeeded at Calgary by **B. M. Woofter,** formerly assistant chief petroleum engineer.

George T. Hansen, founder of **Utah Southern Oil Company,** announced his retirement as chairman of the company's board of directors and as a director. He added that his retirement would become effective at the company's annual stockholders and directors meetings April 21. Hansen served as president of the firm from its beginning in 1921 until his election as chairman of the board in August, 1957. At that time he was succeeded as president by **John E. Rouse,** who continues to serve in this position.

J. T. Cawley, Saskatchewan deputy minister of mineral resources, Regina, Sas-

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katchewan, has been appointed petroleum exploitation advisor on the United Nations Technical Assistance Mission to Pakistan for three months. **E. M. MacKay,** department executive assistant, will serve as acting deputy minister until Cawley's return to Canada.

L. F. McCollum, president of Continental Oil Company, was elected a director of Chrysler Corporation.

Perry E. Barnhart has been appointed district geologist for **Cities Service Oil Co.** in its Lafayette, La., district and **Bill James** has been named to succeed Barnhart as district geologist at Midland, Texas. Barnhart succeeds **B. C. McCasland** who has accepted an assignment with a Cities Service foreign subsidiary.

Global Enterprises Corporation has made several additions to its staff during the past month. **Robert F. Thurrell, Jr.,** has joined the firm as vice president and general manager. He was formerly in Denver for seven years with Geophoto Services, then in Washington, D. C., as executive director of IREX. **H. M. Kirkpatrick** has joined Global as petroleum engineer. Previously Kirkpatrick worked for seven years with Shell Oil Company as exploitation engineer in Tulsa, Houston, Wichita and Denver. Two photogeologists new on the Global staff are **James R. Muhm** and **Bennett F. Brock.**

Robt. F. Terrell, Jr.

T. F. Palmer, assistant division manager of the Houston division of **Sinclair Oil & Gas Company,** has been elected a vice president of the company and named Houston division manager. Palmer succeeds **G. D. Almen Jr.,** vice president, who is being tranferred to Midland, Texas, as Midland division manager. Almen replaces **Floyd Brett,** vice president, who goes to the Tulsa division. **R. M. Kobdish,** assistant manager of the Tulsa division, will be transferred to Houston as assistant division manager to succeed Palmer.

John R. Suman and **Carl E. Reistle, Jr.,** were honored at the recent annual banquet of the American Institute of Mining, Metallurgical and Petroleum Engineers in New York. Suman, a former vice president and director of Humble Oil & Refining Company and Standard Oil Company (New Jersey), received the John Fritz Medal. Reistle, executive vice president of Humble, received the Anthony F. Lucas Gold Medal.

J. D. Richardson has been named division drilling superintendent for **Pan American Petroleum Corp.'s** Rocky Mountain division headquartered in Casper, Wyo. Richardson moves to Casper from Pan Am's Houston division office where he had been drilling research engineer since 1953. He replaces **G. A. Isaacks,** who has transferred to Fort Worth, Texas.

Augustus C. Long, chairman of the board of directors and chief executive officer of The Texas Company, has been elected a member of the board of directors of Freeport Sulphur Company.

Reading and Bates Offshore Drilling Co. has announced four new appointments and transfers throughout their various companies. Promoted from vice president to executive vice president of Reading and Bates is **C. E. Thornton,** whose office will remain in Tulsa. **George L. Temple,** general manager of the firm at the New Orleans office, assumes the additional duties of vice president. Formerly at the Calgary office of Reading and Bates Drilling Co., Ltd., **Frank J. Garnett** has been transferred to New Orleans as assistant to Temple. **N. Glen Watson,** previously with the Oklahoma City office of Reading and Bates, Inc., has been moved to the Calgary office as assistant to **Steven W. Shambaugh,** vice president and general manager of Reading and Bates Drilling Co., Ltd.

Stanley C. Hope, president of **Esso Standard Oil Company,** has accepted the chairmanship of the United Negro College Fund's 15th annual nation-wide spring appeal. He will head the campaign to raise support for the Fund's 33 private member colleges. He will direct the work of volunteers in more than 120 campaign cities across the country.

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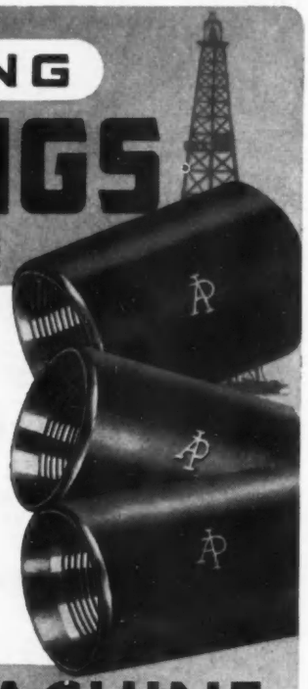

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Falmouth, Mass.—Walter S. Bennett, 53 Minot St.
Grand Rapids, Mich.—R. W. Lang, Jr., 138 Burton SE
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Independence, Mo.—Craig A. Fross, 3701 Norwood
Los Angeles, Cal.—James A. Riordan Co., 1400 Santa Fe Ave.
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Newark, N. J.—Ira L. Rothenberg & Assocs., 398 Market St.
New York, N. Y.—Max Rothenberg, 11-05 38th Ave., Long Island City
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Seattle, Wash.—Ashe & Jones, 819 Thomas St.

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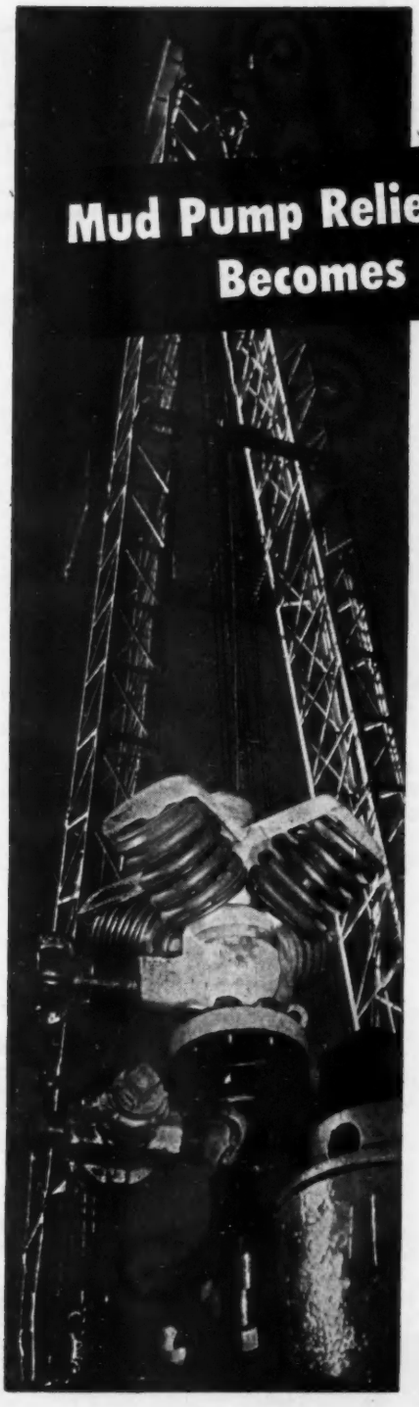
WHO'S MEETING WHERE

APRIL	
1– 3	Corrosion Control Short Course, Fifth Annual, University of Oklahoma, Norman, Okla.
9–11	API Mid-Continent District, Division of Production, Biltmore Hotel, Oklahoma City.
10	ASME, Production Engineering Conference, Bancroft Hotel Worcester, Mass.
17–18	AIME Gas Technology Symposium, Lou-Ark, East Texas and Mississippi Petroleum Sections, Shreveport, La
17–18	Geophysical Society of Tulsa and Tulsa Geological Society, Eleventh Annual Midwestern Exploration Meeting, Tulsa.
17–18	West Texas Oil Lifting Short Course, Fifth Annual, Texas Technological College, Lubbock, Texas.
17–19	San Angelo Geological Society, Third Bi-Annual Field Trip, Base of the Permian, Brownwood Hotel, Brownwood, Texas
21–23	API Division of Production, Rocky Mountain District, Cosmopolitan Hotel, Denver.
23–25	Saskatchewan Geological Society and North Dakota Geological Society, 2nd International Williston Basin Symposium, Regina
27–29	Independent Petroleum Assn. of America, Midyear Meeting, Hotel Sherman, Chicago
27–30	AAPG, Rocky Mountain Section, Annual Convention, Natrona County Fairgrounds Industrial Building, Casper, Wyo.
28–29	Automatic Control in Petroleum and Chemical Industries Short Course, Third Annual, University of Oklahoma, Norman, Okla.
MAY	
5– 6	AIME, North Texas Section, Third Biennial Secondary Recovery Symposium, Wichita Falls, Texas.
7– 9	API Division of Production, Eastern District Meeting, Deshler-Hilton Hotel, Columbus.
8– 9	Texas Petroleum Research Committee, Eleventh Oil Recovery Conference, the University of Texas Campus, Austin, Texas.
11–15	ASME, Oil & Gas Power Conference and Exhibit, Bellevue-Stratford, Philadelphia, Penn.
21–23	Rocky Mountain Oil and Gas Assoc. Thirteenth Annual convention, Denver, Cosmopolitan Hotel.
22–23	API Division of Production, Pacific Coast District Meeting, Biltmore Hotel, Los Angeles.
JUNE	
2–4	PESA, 30th Annual Meeting, Texas Hotel, Fort Worth, Texas.
8–13	API Division of Production, Midyear Committee Conference, Hotel Deauville, Miami Beach, Fla.
15–19	ASME, Semi-Annual Meeting, Statler Hotel, Detroit, Mich.
18–28	Chemical & Petroleum Engineering Exhibition, London
19	Pennsylvania Grade Crude Oil Assn., Annual Meeting, Penhills Club, Bradford, Penn.
23–25	Interstate Oil Compact Commission, Midyear Meeting, Hotel Utah, Salt Lake City.
28 to July 2	PESA, 23rd annual Meeting, Chateau Frontenac, Quebec, Canada.

Nomads' Chapter monthly meeting: Los Angeles, second Wednesday, Jonathan Club, Wallace A. Sawdon, Secretary. Houston, second Monday, Ye Old College Inn, Harry E. Estes, Secretary. Dallas-Fort Worth, first Monday, Greater Dallas Club, Hank Davis, Secretary. Tulsa, Hotel Tulsa, Gilbert Swift, Secretary. New York, first Monday, Hotel Biltmore, Jesse E. Hickman, Seceretary.



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As mud pumps are necessarily operated at near capacity to meet the constantly increasing demands on drilling circulating systems, the safety demands on the relief valve become greater.

Responsibility for reducing hazards of personal injury, equipment damage and drilling trouble by relief of excessive drilling mud pressures, calls for a valve that assures positive instantaneous pressure relief at maximum volume and automatic restoration of circulation upon correction of the overloading condition. These requirements have been accomplished in the Kinzbach Model 112 Pressure Relief Valve by combining two unique methods of restraining the valve piston, yielding a characteristic action from a decreasing force against the valve piston on opening movement, and conversely, an increasing force during closure. This assures higher effective lift during valve action.

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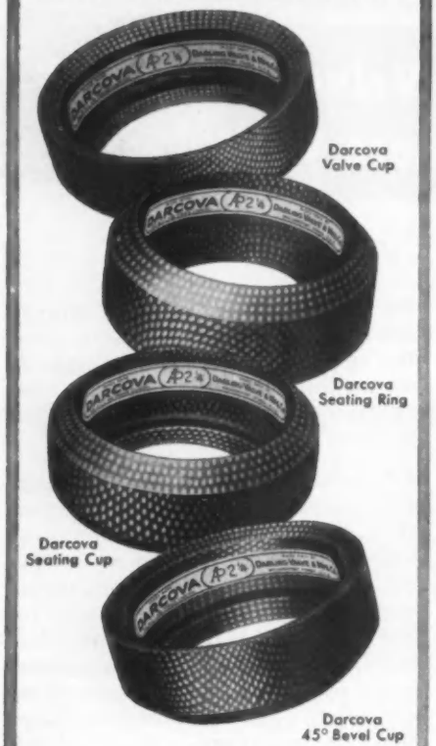

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DEATHS

W. P. Tomson, 75, retired oil man, and formerly connected with the Power Oil Co., died January 30.

Carl J. O'Hornett, 74, president of the George Oil Co., died January 10. He formerly headed the Union Oil Co.

Irving Boyd Hamilton, 39, head of the Paleontology department for the Sun Oil Co., Dallas division, died February 3.

Sam Bennett, 64, president of St. Francis Oil Co., partner in King Petroleum Co. and former president of South Belridge Oil Co., died February 3 in a Los Angeles hospital.

John G. Catlett, 72, independent oil producer and royalty owner, died February 7.

Frank A. Haskell, 89, died February 10. He was a charter board member of the American Petroleum Institute and helped bring about the organization of the Mid-Continent Oil and Gas Association in 1917. He was elected first president of the association. Haskell was also director and vice president of the Tide Water Associated Oil Co.

B. F. (Hank) Wiley, a geologist for Humble Oil Co., died February 1 in a helicopter crash two miles south of Grand Isle, La.

J. A. Ledet of Rowan Drilling Co., died February 1 in a helicopter crash two miles south of Grand Isle, La.

F. W. Bergeron, of Rowan Drilling Co., died February 1 in a helicopter crash two miles south of Grand Isle, La.

William Palmer Lawrence, 47, geophysical party chief for Amerada Petroleum Corp., died February 6.

John W. Naylor, 62, for many years oil editor of the Fort Worth Star Telegram, died January 31. He was also in the lease and production of the oil business.

Clarence G. Armstrong, 70, president of Armstrong Petroleum Co., died February 6.

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AAPG and SEPM Install Officers at Joint Meeting

The national American Association of Petroleum Geologists and the Society of Economic Paleontologists and Mineralogists installed 1958-59 officers at their annual joint meeting March 10-13 in Los Angeles.

George S. Buchanan, director, Husky Oil Company, became the forty-second president of the AAPG. Gordon Rittenhouse, Shell Development Company, Houston, is the new president of the SEPM.

Serving with Buchanan on the 1958-59 Executive committee will be Graham B. Moody, consulting geologist, Berkeley, Calif., as past president; the present editor of the AAPG monthly Bulletin of Petroleum Geology, Sherman A. Wengerd, professor of geology, University of New Mexico, and two other newly elected officers: Vice President Gordon I. Atwater, senior member of Atwater, Cowan & Associates; and Secretary-Treasurer Harold T. Morley, chief geologist, Pan American Corporation.

Serving with Rittenhouse on the 1958-59 council will be R. V. Hollingsworth, Paleontological Laboratory, Midland, Texas, as past president; W. M. Furnish, Iowa State University, vice president; Raymond E. Peck, University of Missouri, secretary-treasurer; M. L. Thompson and Charles W. Collinson, Illinois State Geological Survey, co-editors of the *Journal of Paleontology;* and Jack L. Hough, University of Illinois, editor of the *Journal of Sedimentary Petrology.*

Paul Weaver, professor of geology, Texas A & M College, received the Sidney Powers Memorial Medal from the AAPG.

Certificates of honorary membership were presented to Carroll Edward Dobbin, U.S.G.S.; K. C. Heald, petroleum consultant; William Bayard Heroy, Geotechnical Corp.; A. I. Levorsen, consultant; Raymond C. Moore, state geologist of Kansas; and Wallace E. Pratt, consulting geologist.

The SEPM elected three honorary members. They are Marcus Albert Hanna, Gulf Oil Corp.; Charles Elijah Decker, professor emeritus at the University of Oklahoma, and Hans Ernst Thalmann, Stanford University.

Keynote speaker, Monroe E. Spaght, executive vice president and a director of Shell Oil Company, addressed the first day's joint session of the two societies.

what's Happening

among INDUSTRY ASSOCIATIONS

Honors for Education

D. F. Garrett, right, accepts a bronze plaque honoring the Permian Basin chapter of the American Association of Oilwell Drilling Contractors for its contributions to the School of Drilling Technology at Odessa, Texas. J. U. Teague, Houston, national AAODC president, presented the award at a recent chapter meeting. Looking on are Brad Mills, left, AAODC executive vice president, and Ed Durrett, former Permian Basin chapter chairman.

Major Organization Change Made by IPAA Executives

The first major reorganization in the history of the 29-year-old Independent Petroleum Association of America was formalized this week by its Executive committee and announced by IPAA President Gordon Simpson.

The changes involve creation of five functional departments responsible for the association's activities in government relations, statistical and economic studies, public and industry information activities, membership extension and administrative affairs.

Minor S. Jameson, Jr., a member of the IPAA staff since 1937, was elected executive vice president and was designated to coordinate departmental activities and the over-all program of the association.

Other departments formally established under the reorganization include:

Administration and Finance, which has charge of all business and financial affairs of the association under I. C. Huff, Jr., executive manager and secretary.

Membership department, headed by B. H. Vickrey as membership director.

Information Department which has responsibility for planning and coordination of both public and industry information activities under Lloyd N. Unsell, director of information.

New York Visitors and Guests

Approximately 162 NOMADS and guests attended the recent New York chapter meeting. Visiting NOMADS and guests are (left to right, seated) W. F. Faulk, H. C. Smith Oil Tool Co.; Howard Reid, Totco and Lucey Export Co.; Ashley Moore, Socony-Mobil Oil Co.; S. P. Stone, Creole Petroleum Corp.; and Harry Snady, Arabian American Oil Company. (Left to right, standing) George P. Daley, Continental-Emsco Co.; Jesse Benson, Petromac; B. J. Gross, WKM Co.; J. P. Magoffin, Byron Jackson Co.; J. W. Martin, Aramco Overseas Co.; and George Haley, Beckley, Haltom & Hickman.

Tulsa Holds First Meeting

New officers of the Tulsa chapter NOMADS held their first business meeting recently in the Tulsa Club. Pictured from left are Harry Horton, treasurer; W. O. Timberlake, assistant secretary; John Pearce, president; Vern Bailey, sergeant at arms; E. L. Thomas, executive secretary; Floyd Cummings, assistant treasurer, and Guy Williams immediate past president and senior regent. Other officers for 1958 are Paul McGivern, junior regent; Oscar Irizarry, vice president; T. M. Lumly, secretary; and E. M. Donovan, deputy sergeant at arms.

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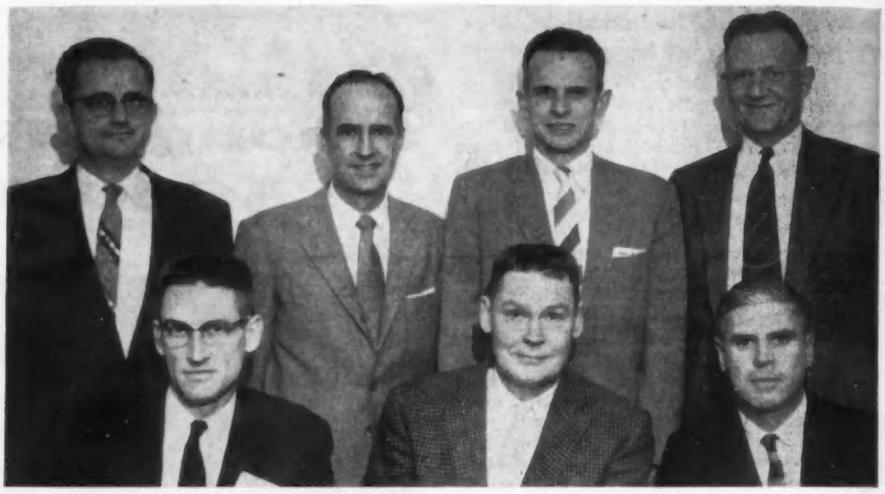

New Rocky Mountain Geologist Officers

Officers of the Rocky Mountain Association of Geologists for 1958 are left to right, seated: Daniel S. Turner, first vice president, Dan Turner & Associates; Andrew G. Alpha, president, Signal Oil & Gas Co.; Laurence Brundall, past president, Geophoto Services; Standing, Henry H. R. Sharkey, second vice president, The Carter Oil Co.; William A. Newton, councilor, consulting geologist; Joseph B. Headley, secretary-treasurer, Southwood Exploration Co.; and F. A. Thurman, councilor, Thurman consultants.

Houston NOMADS Hear Baker

Warren Baker, editorial director of WORLD OIL, was the principal speaker at a recent meeting of the NOMADS in Houston. From left to right, back row, are Frank Pritchard, Cameron Iron Works; A. Villarroel, Y.P.F.B. in Bolivia; Francisco Noqueida, Petrobras Brazil; Simon Stein, Petrobras Brazil; Baker; G. R. Olsen, Pure Oil Co. of Paraguay; and Wesley P. Brandon, Reed Roller Bit Co. Left to right, front row: A. J. Organ, Reed Roller Bit; R. L. Holden, The Texas Co. of Va.; Jose Yabar, The Barmine Co.; Jose Luis Gutierrez, Equipos Petroleros Nac; E. P. Bravo, Equipos Petroleros; and R. F. Seidel, Mobil Overseas Oil Co., Inc.

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API Southwest Production Elects 1958 Chairmen

The five-state Southwest district of the American Petroleum Institute Division of Production ended its recent three-day technical meeting in Houston with the election of new officers.

Roy A. Bobo, Phillips Petroleum Co., Houston, was named district chairman to succeed Ben F. Carter of Shreveport.

Vice-chairmen named were Walter Kalteyer, Hunt Drilling Co., chairman for Southwest Texas; Earl Thomas, Sun Oil Co., Southwest Louisiana; Charles D. Schultz, consultant, Balcones area; C. J. Russell, Arkansas Fuel Oil Corp., Ark-La-Tex Area; Isaac Ault, Magnolia Petroleum Co., southern Louisiana; W. W. Wilson, Lane Wells Co., Rio Grande Valley; Joel Battle, The Texas Co., Texas Gulf Coast; Sam Cox, East Texas Engineering Association, East Texas; W. L. Massey, Alcoa, south central Texas; and J. B. Flemming, Welex, Inc., was elected district secretary-treasurer.

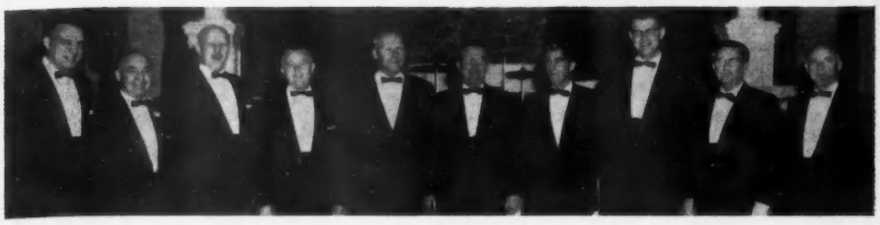
Ben F. Carter, Union Producing Co., becomes chairman of the district advisory committee.

Dallas Geological Society Elects 1958 Officers

The new officers of the Dallas Geological Society for 1958 are Norman C. Smith, president, photogeological consultant; Dan E. Feray, first vice president, Feray Geological Service; Peter N. Wiggins III, second vice president, Wiggins Brothers, Inc.; Paul W. Foster, secretary, Atlantic Refining Company; and Phil Porter, treasurer, DeGolyer and MacNaughton.

District representatives are H. J. Morgan, Jr., H. Rogatz, M. M. Garrett and W. G. Meyer.

W. Dow Hamm, Atlantic Refining Company, is chairman of the 1959 Convention Committee.



Los Angeles NOMADS Elect Officers

The new officers of the Los Angeles chapter of NOMADS for 1958 are shown here at the chapter's nineteenth annual Inaugural Ball held in the Biltmore Bowl, Los Angeles, recently. From left to right: H. J. Schlarb, Continental-Emsco Co., master of ceremonies; P. M. Bowen, Martin-Decker Corp., assistant treasurer; C. F. Van Loozen, Macco Corp., treasurer; Tom R. Ashe, Globe Oil Tools Co., sergeant-at-arms; Wm. (Andy) Anderson, Pacific Perforating Co., deputy sergeant-at-arms; Earl M. Daniels of Hydril Co., president; Knight Templeton, S. R. Bowen Co., secretary; Robert P. Gaylord of Wagner-Morehouse, Inc., regent; Taylor Bannerman, Technical Oil Tool Corp., assistant treasurer; Harry E. Hester, McCullough Tool Co., regent. Not shown, Earle R. Atkins, Devex Engineering Co., vice president.

M. F. Clegg, chapter AAODC chapter chairman, (right) presents the check to C. V. Kirkpatrick, who accepted in behalf of the library. Kirkpatrick is chairman of the University of Houston's Petroleum Engineering department.

Houston AAODC Enlarges Technical Library at UH

The Houston Chapter, American Association of Oilwell Drilling Contractors, recently presented a check for $500 to the University of Houston Library for the purchase of technical reference books. In addition, the chapter will present copies of books published by AAODC.

Signifying AAODC's interest in education, the money and books will form the nucleus of a new reference library, which will be located in the Petroleum Engineering department.

Kantzer Named 1958 Head For Petroleum Engineers

Basil P. Kantzer, manager of operations of the Gulf division of the Union Oil Company of California, was installed as 1958 president of the Society of Petroleum Engineers of AIME at the annual AIME meeting recently in New York.

Vice presidents for 1958 are B. L. Francis, assistant division manager for The Texas Company, New Orleans, and E. N. Van Duzee, production manager of Shell Oil Co.'s Midland, Texas, area.

Also installed were five new members of the Society of Petroleum Engineers board of directors who will begin serving staggered terms in 1958:

R. A. Morse (three-year term), associate director of research for Gulf Research & Development Co.; Harry D. Campbell (three-year term), president and general manager of Franco Western Oil Co.; Roy A. Bobo (three-year term), director of the Drilling Engineering division of Phillips Petroleum Co.'s Production Department; Raymond E. Howard (two-year term), regional petroleum engineer of the West Texas—New Mexico region for The Atlantic Refining Co.; and Raoul J. Bethancourt (one-year term), division staff petroleum engineer for the Sun Oil Co.

New Committee Formed For Oil Public Relations

A new high level committee to direct a program to inform the public about the oil industry in the five Western states was announced by Samuel F. Bowlby, president of the Western Oil and Gas Association.

The committee is to be known as the West Coast District Oil Information Committee.

Chairman is W. G. King, Jr., vice president, Richfield Oil Corporation. The executive vice chairman is Selwyn Eddy, vice president, Shell Oil Company.

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What's Happening among SERVICE and SUPPLY MEN

Tom E. Morton

Walton J. Greer

Tom E. Morton has been named executive vice president of **Welex, Inc.** Morton has been vice president in charge of operations since October, 1957, when Welex Jet Service, Inc., and the Electrical Well Services department of Halliburton Oil Well Cementing Company were consolidated. In the same announcement, **Walton J. Greer** was named vice president of Welex in charge of all Welex engineering and research with his offices in the Welex Research Laboratory in Houston. Greer has been director of research and engineering since the consolidaton of Welex Jet Services, Inc., and the Halliburton Electrical Well Services Department and held the same position with the EWS department prior to that time.

Fairbanks, Morse & Co., has announced the retirement of **Harry J. Renken,** manager of the Oil Field division, and the appointment of **W. S. Johnson** for that same position. Johnson has been for a number of years manager of the Diesel department of the Dallas branch until his recent appointment.

Page Oil Tools announced the addition to the Page field sales and service staff of **Nick R. Dirksen.** Dirksen worked as a salesman for the O'Meara & Rogers Construction Company from 1955 to 1957 for whom he represented a general line of oil well equipment. He had previously spent 14 years with Sargent Engineering Corporation as a pump salesman.

Nick R. Dirksen

Loffland Brothers Company has announced several important promotions in the company. **Kenneth E. Chaffin** has been made general superintendent of the Louisiana-South Texas division, succeeding **George C. Mallory. D. E. Williams** has been promoted to assistant general superintendent of the Louisiana-South Texas division. Both Chaffin and Williams will make their headquarters in the company offices in New Iberia, La. **Paul L. Waid** has been made assistant superintendent of operations of Loffland Brothers Company of Canada. He will make his headquarters in Calgary, Alberta.

Johnston Testers, Inc., has named **John H. Flanagan** as manager of field operations and **Bob Graham** as personnel manager. Other new assignments include the appointment of **Lastie Paul Vincent, Jr.,** as technical assistant to the manager of field operations and **Buddy R. Dixon** as administrative assistant to the manager of field operations. Flanagan formerly was personnel manager. As manager of field operations, he will be responsible for coordinating all field activities including testing, perforating, transportation, inventory and budgets. Graham was appointed personnel assistant in July, 1957, and has served in that capacity since that date.

Jesse T. Berger has been named director of industrial relations for the **Byron Jackson Division** of **Borg-Warner Corporation.** For the past four years he has been director of industrial relations for Lane-Wells. Prior to that he held responsible positions in the field of industrial relations and personnel administration with Pacific Airmotive Corporation and Standard Oil of California. He was also assistant chief of the Industrial Relations division of the San Francisco Port of Embarkation, in both military and civilian capacities.

Jesse J. Burger

William H. Shenkle, chief engineer of **Rockwell Manufacturing Company's** Instrument division at Tulsa, has been promoted to general manager. Shenkle joined Rockwell in 1953 as a product engineer at the Tulsa instrument plant.

David Clinton Kelley has been appointed sales and service representative for **Cabot Shops, Inc.,** and **Franks Division** of Cabot in Anaco, Venezuela.

Republic National Bank of Dallas announced the promotion of 17 staff members. **David C. Grimes** was promoted from assistant vice president to vice president; **J. Frank Fields, James R. Mason, Vincent E. Thompson,** and **James C. Wilson, Jr.,** were promoted from assistant cashiers to assistant vice presidents. **L. E. Elder** was

promoted from assistant auditor to assistant cashier, and **George E. Wilkin, Jr.**, was promoted to trust officer. Ten other staff members were elected assistant cashiers. They are **Billy J. Clift, John Davis, Alfred F. Edwards, Lynn Helm, James H. Jones, G. V. McGee, James Montgomery, Jack Nowlin, Lee Drain** and **John C. Johnson.**

J. P. Magoffin has been appointed as European sales manager of **Byron Jackson Tools, Inc.** The new post was created to facilitate sales of all BJ oil field equipment—including cementing and fracturing units and PB rubber products—and to bring about a closer, more personalized relationship between Byron Jackson and its cusotmers in Europe and the Middle East. Magoffin has been with BJ for 15 years. He was sales manager of the Patterson-Ballagh organization (PB rubber products) at the time it became part of Byron Jackson. He opened and managed the first Mid-Continent office that combined the products and services of the two organizations.

J. P. Magoffin

G. T. Armstrong has been named vice president and division manager of the newly organized Panhandle-North Texas division of **Welex, Inc.**, in Dallas.

Warren E. Moore, formerly production engineer with Haynesville Operators Committee, has joined **Tretolite Company** as corrosion engineer. He is located at Bossier City, La., and will cover the East Texas and North Louisiana area. He succeeds **James W. Hakeman**, formerly senior corrosion engineer for Tretolite Company at Shreveport, La.

Cummins Sales & Service de Venezuela, C. A., recently announced the appointment of **Leo J. Troutz** as vice president. General office for Cummins Sales & Service de Venezuela is in Caracas. Troutz will continue as general service manager of Cummins Sales & Service, Inc., Fort Worth, and divide his time between the two organizations. He has been with the Fort Worth company since 1943.

Schlumberger Well Surveying Corporation has announced six new assignments. **W. A. Eickmeyer**, for many years manager of the Abilene, Texas, district, is now division sales manager in Dallas. **R. G. Tefft**, formerly district manager at Andrews, Texas, replaces Eickmeyer as manager at Abilene. New manager at Andrews is **G. F. Horst. L. F. Holdman** is the new sales engineer at Mt. Vernon, Ill. **Burton Delleney**, formerly division sales manager in Dallas, has been transferred to the Patent

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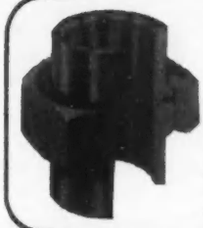

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department in the Houston headquarters. **V. J. Davis** has been promoted to sales engineer at Gainesville, Texas. Davis formerly was field engineer for that area.

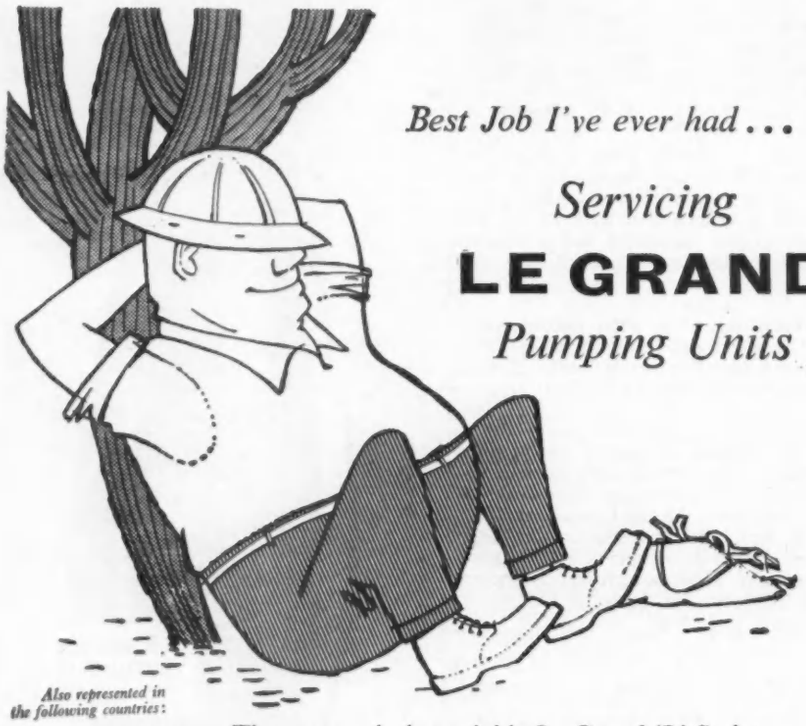
Herbert C. Otis, Jr., first vice president of Otis Engineering Corp., Dallas, has been elected chief of the Dallas Emergency Corps.

B. J. Travis was appointed assistant district engineer, secondary recovery sales, at Midland, Texas, for **United States Steel Corporation's** Oil Well Supply division. Travis was employed by Oilwell in 1952 at Odessa, Texas. In 1954 he was appointed assistant district engineer, machinery and equipment sales, at Odessa. Prior to his present appointment he was employed at Odessa.

Sam McCleneghan was appointed a project engineer by **Stewart & Stevenson Services, Inc.** McCleneghan was one of the founders of the Valley Manufacturing Company in Valley, Nebr., and was associated with that company for 17½ years prior to joining Stewart & Stevenson.

W. H. Leo has been appointed manager of sales at Sheffield's Division, Armco Steel Corporation's Houston plant. Leo succeeds **R. W. Davison**, who has been promoted to director of sales planning and coordination at Armco's headquarters in Middletown, Ohio. During the past five months, Leo has been on leave from his position as manager of sales for construction products in Kansas City to serve as director of the Iron and Steel division of the Business and Defense Services Administration.

In Kansas City, Leo will be replaced by **D. W. Roberts**, who is manager, sales services, at the Houston plant. Roberts will be succeeded in Houston by **E. L. Argo**, who was assistant manager of sales, bolt products, in Kansas City. In that capacity, Argo will be replaced by **A. D. Johnston**, formerly district manager, Kansas City area. Leo joined Sheffield in November of 1941 as district manager of the Oklahoma City office.



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F. L. McFarland

D. T. Ottinger

Jones & Laughlin Supply Division has announced the formation of three new regions. The appointment of three regional managers and five new district managers were simultaneously announced. **D. T. Ottinger,** formerly district sales manager of the South Texas district, has been appointed regional manager of the Gulf Coast with headquarters at Houston. Under his supervision will be the Southern Louisiana district, New Orleans, **C. E. Rogers,** manager; the South Texas district, Houston, **L. P. Mackey,** newly appointed manager; and the Southwest Texas district, San Antonio, Texas, **C. H. Maxwell,** manager. Also included in the Gulf Coast region are city sales offices at New Orleans, Houston and San Antonio. **F. L. McFarland,** formerly district manager, West Texas, was appointed regional manager for the Southwest region with headquarters at Midland, Texas. This region is made up of the West Texas-New Mexico district, headquartered at Odessa, Texas, **Glenn A. Whiteker,** newly appointed manager; the Central Texas district, Abilene, Texas, **H. H. Ray,** newly appointed manager; and the present Panhandle district headquartered at Amarillo, Texas, **H. U. Everett,** manager. In addition, the Southwest region includes city sales offices at Midland and Amarillo.

D. H. Carson

D. H. Carson was named regional manager of the Rocky Mountains with headquarters at Denver. Under this region will be the North Rocky Mountain district, headquartered at Billings, Mont., **M. A. Park,** manager; Central Rocky Mountain district, Casper, Wyo., **G. E. Best,** newly

appointed manager; South Rocky Mountain district, Farmington N. M.; **J. W. Johnson,** newly appointed manager. The Rocky Mountain region also includes the Denver and Billings city sales offices.

The Weatherford Oil Tool Company, Inc., has announced a number of important promotions. **Homer Longino** has been appointed vice president in charge of sales and **Bill Louderback** will be assistant vice president in charge of sales. **Robert P. Turnbull** has been named vice president of sales for Weatherford, Limited in Edmonton, Alberta, Canada. He was sales and service engineer in the Houston area.

W. C. Norris, division of Dover Corporation, announced these additions to the sales staff. **Homer Hill** is now located at Ardmore, Okla. **Jack Connell** is at Houston. **Barron Preslar** succeeded **Jack Getty** at Shreveport, La., when Getty advanced to the Tulsa office. **George White** is now at Hobbs, N. M. **Earl Carpenter** is now working in the northern Oklahoma and Kansas area.

A. C. (Al) Poujol has joined the sales staff of the **Coastal Supply Company, Inc.** Poujol was previously with the Shell Oil group for 13 years. He will be assigned to the Houston area.

Richard E. White, president of Mission Manufacturing Company, was elected to the board of directors of **Houston Bank & Trust Company.**

Applied Power Equipment & Mfg. Co. has moved **Ernest E. Collinsworth** from Alice, Texas, to McAllen, Texas, where he will operate as District Manager Bob Hays' assistant as a branch of the Alice store.

B. Price

C. Harrison

S. Matheny

Ideco, Inc., one of the Dresser Industries, has appointed three technical service representatives. **Berwin L. Price** has been transferred from Ideco's Sales department in Dallas to Beaumont where he will headquarter at the Ideco plant there. He will represent Ideco in the Gulf Coast area. **Charles W. Harrison** has joined the company at the Houston office and will also have technical service responsibilities in the Gulf Coast area. On the West Coast **Shannon L. Matheny, Jr.,** has been added to the Ideco California oil field sales organization and will headquarter at Ideco's Long Beach office. He was formerly with Standard Vacuum in Indonesia and Continental Oil Company in California.

James Whitaker, a veteran **Christensen Diamond Products Company** employe, will return to the United States sometime in

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April. Whitaker, for the last two years, has been representing Christensen's in the Near East, making his headquarters in Beirut, Lebanon. Upon his return to the States, he will be located at Christensen's main office and plant in Salt Lake City, Utah. **Percy Tinsley,** former Gulf Coast area representative for Christensen Diamond, will become their new representative for the Near East.

Schlumberger Well Surveying Corporation has made seven new field assignments. New sales engineer at Laurel, Miss., is **F. E. Kendrick.** Moving to Farmington, N. M., as division engineer is **P. H. Hines,** who formerly was location manager at Donaldsonville, La. **Van Maraman** has been transferred from Tyler, Texas, to Wichita Falls, Texas, as sales engineer. **F. Perkins,** formerly senior sales engineer at Wichita Falls is now in Lubbock, Texas, as location manager. **E. A. Colle,** formerly associated with the New Orleans office, has been promoted to assistant manager of the Mid-Continent area at Tulsa. **R. E. Hamilton,** former district manager at Lubbock, has been promoted to senior sales engineer for the Permian Basin division at Midland, Texas. **V. J. Davis** has been named sales engineer at Wichita Falls.

H. K. McArthur has been named vice president and manager of the Texas Gulf Coast division of **Welex, Inc.** Division offices are in Houston.

Continental-Emsco Company announced the promotion of **Jack Amerman** to chief engineer and **Jack Eldridge** to chief engineer mechanical. **Virgil Clark** is presently chief engineer of structural. All three men are located at the oil field supply and manufacturing company's plant in Houston.

W. C. Hale Jr.

L. A. Estes

South Chester Tube Company has announced the election of **W. C. Hale, Jr.,** as president. He has also been elected chairman of the board of the Tube Company's subsidiary, Dodge Steel Company. He will continue to serve in his present capacities as president of Dodge Steel Company, and of South Chester Corporation. Hale also continues as president of Southco's subsidiary, Lion Fastener Co., Inc., and as executive vice president of Chester Tidewater Terminal. **L. A. Estes,** in retiring as board chairman of Dodge Steel, South Chester, and Lion Fastener and as president of South Chester Tube, will continue to serve as president of Chester Tidewater Terminal.

Jug Davis has joined the **Brown Oil Tool Company** as a sales engineer and has established a Brown service and administrative office in Dallas to serve the Dallas-Fort Worth area.

David C. Guinn has joined **Shaffer Tool Works, Inc.,** as division engineer in the Mid-Continent Gulf Coast area.

James H. Doiron, formerly head of the Grinding department at the Houston plant of **Herb J. Hawthorne, Inc.,** has been appointed superintendent of the company's new branch plant operation at Midland, Texas.

E. E. (Bill) Williams, formerly of the Technical Oil Tool Corporation, has joined the **Lucey Export Corporation.** Williams will be stationed in Houston and will cover primarily Mexico and northern South America for Lucey Export.

Charles H. Williams was appointed administrative vice president—engineering and **James B. Austin,** administrative vice president—research and technology, of **United States Steel Corporation.** Williams was formerly assistant executive vice president—engineering and raw materials. Austin was formerly vice president—research and technology.

E. F. Greiwe was appointed manager of the Norwood Works Centrifugal Pump department of **Allis-Chalmers Manufacturing Company.** He succeeds **M. L. Murdock,** resigned.

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Bethlehem Supply Meet

Bethlehem Supply Company held its annual sales meeting at Western Hills Lodge on Lake Gibson near Wagoner, Okla., recently. Attending the conference were (left to right, front row) L. V. Nowlin, Arthur Weber, Jr., L. R. Estes, H. A. Barnes, L. G. Bettis, V. G. Stahl, O. H. Crowe, F. I. Mobley, G. V. Furrow, I. C. Smith, G. B. Sager, H. E. Davidson, R. L. Timmons and J. V. Spalding. (Second row) C. H. Wilmeth, H. R. Powers, Christian Seger, Jr., H. A. Wilson, D. L. Brown, Lee Fagg, Wendell M. Jones, F. R. House, President C. R. Zimmerman, J. F. Eaton, D. C. Thomas, W. J. Brady, J. B. Ellzey. (Third row) L. A. Myers, V. W. Bailey, G. L. Reid, W. E. Stephenson, E. R. Phillips, H. V. Harder, W. T. Davis, C. R. McNair, E. S. Lewis, W. M. Sanders, T. C. Graham, T. M. Tallon, W. F. Taylor, P. H. Jezzard, R. B. Dearing, J. G. Floyd, R. A. Johnson, C. C. Crider, S. A. Barnes and H. L. Hawkinson.

Mid-Continent Supply to Handle Unit Rig's Drilling Equipment

Under terms of a new marketing arrangement, the complete line of drilling equipment manufactured by Unit Rig & Equipment Company will now be sold by Mid-Continent Supply Company and will carry the Mid-Continent name.

Unit Rig & Equipment Company's manufacturing facilities will not be affected by the move and will continue to operate as they have in the past.

Petroleum Equipment Company To Begin Venezuelan Operations

A newly-formed petroleum equipment corporation has announced its plans to start operations in Venezuela soon.

Equipo Petrolero Compania Anonima will be incorporated with a capital structure of 75,000 bolivares and will be known by the abbreviated name of EPECA.

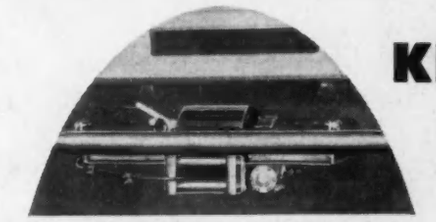
Officers of EPECA include Robert E. Murphy, president; Ed T. Malloy, executive vice president; and Lamar W. Davis, Jr., vice president in charge of engineering.

EPECA will engage in the sales and service of Harold Brown Company gas-lift equipment.

Lone Star Steel Co. Reduces Production in Morris County

Lone Star Steel Company announced a reduction in production at its plant in Morris County, Texas. About 1500 employes were affected by the order to reduce work schedules.

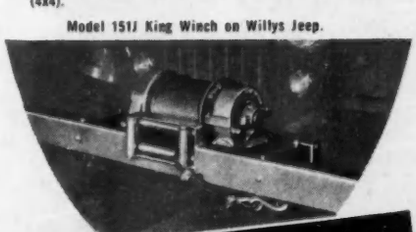
Departments hardest hit at the East



Model A-11 King Winch on A-120 (4x4) all-wheel-drive International truck.*

Model CD-8116 King Winch on 1958 Chevrolet Model 31 (4x4).

Model 151J King Winch on Willys Jeep.



KING WINCHES

. . . for Willys, International, Chevrolet, GMC, Ford, Land Rover and other vehicles

COMPLETE, READY-TO-INSTALL KING FRONT-MOUNT WINCH ASSEMBLIES FEATURE:

- winch side arms to reinforce truck frame
- bronze-bushed, 4-way cable guide rollers
- cable drum guard
- heavy-duty pipe bumper
- needle-bearing, universal-joint spline-shaft drive assembly
- Timken bearings on worm

King Winches keep you moving through the most difficult terrain . . . you get action where there's no traction with dependable pulling power. King power winches have pulling capacities of 8,000 to 19,000 lbs.

* *King Winches for International trucks are available through International-Harvester dealers.*

Koenig ALL-STEEL CABS FOR JEEPS

FULL AND HALF CABS

Full Cab and Model 151J King Winch Illustrated.

Koenig Jeep cabs and King Winches for Willys vehicles are available through Willys Motors, Inc., and Willys-Overland Export Corp. distributors or dealers. Write for free descriptive literature.

KOENIG ALL-STEEL CABS HAVE THESE SUPERIOR FEATURES:

- PROTECTION
- SAFETY
- COMFORT
- CONVENIENCE

Roll-down windows, full opening . . . full panel-board head lining and masonite door lining . . . safety glass throughout . . . all-steel welded construction . . . door locks.

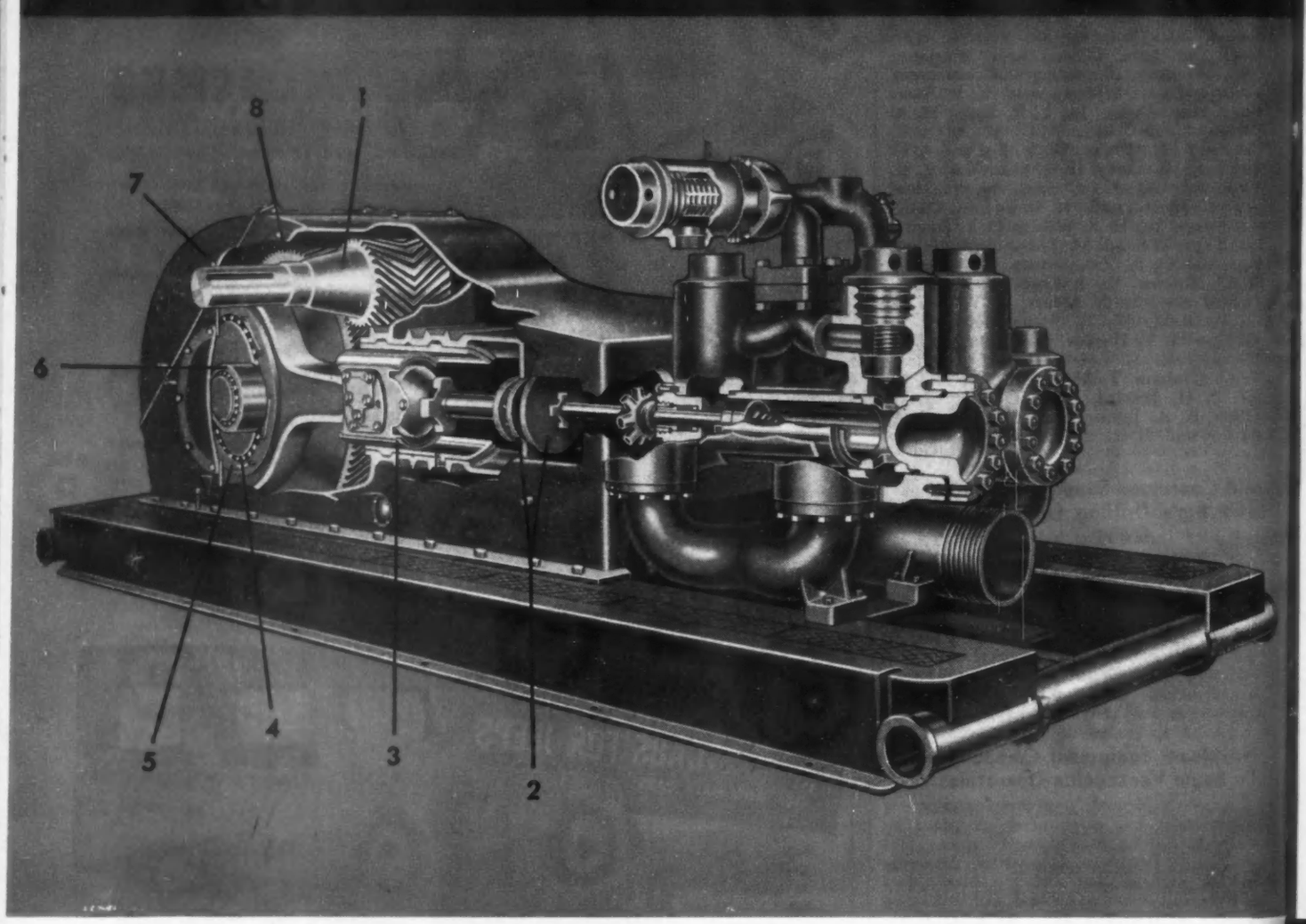
IRON WORKS, Inc.

WEST 12th at ELLA BLVD. P. O. BOX 7726 HOUSTON 7, TEXAS

For more data on advertised products, use Readers' Service Cards, last page.

Reliable

Field Performance.



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MID-CONTINENT SUPPLY COMPANY

FORT WORTH, TEXAS

Export: Mid-Continent Supply Co., Inc. • 45 Rockefeller Plaza, New York 20, N. Y.

BOVAIRD SUPPLY COMPANY

TULSA, OKLA.

IN CALIFORNIA

CONTINENTAL-EMSCO COMPANY

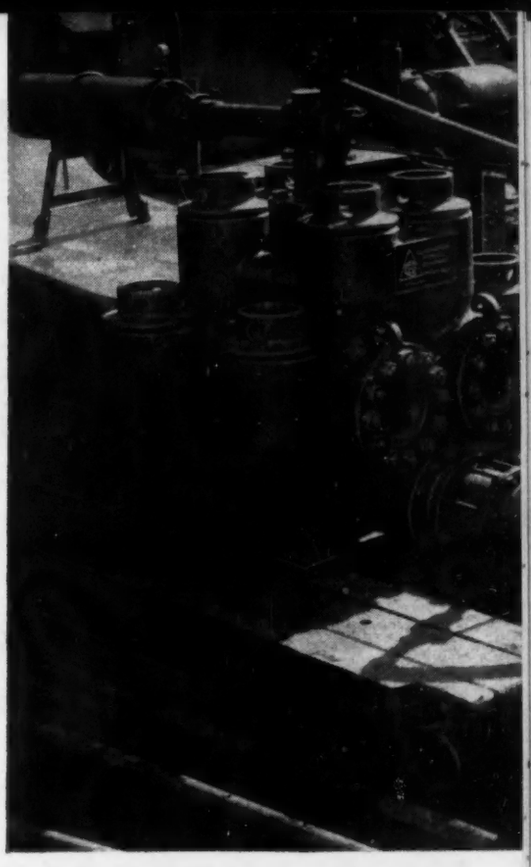
is insured by

Continental-Emsco Power-End *design*

By the cross sectional drawing, you can see why Tool Pushers and Drillers place so much reliance in the power ends of Continental-Emsco slush pumps. In addition to their rugged construction, these power ends are surprisingly lightweight due to their *Fabriform* construction. In this new concept of pump design, the conventional heavy, bulky casting has been replaced by steel plates, formed and fabricated into a compact, rigid frame. You get *more horsepower per pound* than in any other slush pump.

POWER END FEATURES

1. One-Piece, Forged-Steel Pinion and Shaft
2. Packing Gland and Rubber Baffle Keeps Mud From Power End
3. Replaceable Crosshead Slippers and Frame Guides
4. One-Piece Eccentric Straps, Equipped With Large-Diameter, High Capacity, Retainer-Type Roller Bearings
5. Combination Splash-and-Pressure Lubrication System
6. Roller Bearings Used Throughout
7. All-Steel, Fabriform Constructed Power End
8. Demountable, Forged-Steel Herringbone Gear



Continental-Emsco "D" Series Slush Pumps give you all these wanted, needed fluid end features

- ★ Precharged Pulsation Dampener
- ★ 360° Swiveling Screen, Protects Discharge
- ★ Heavy, Coarse-Pitch Threaded Valve-Pot Covers
- ★ Cylinder Head Lock Liner
- Shear Relief Valve
- Liners Packed at Both Ends, Exposed to View
- Screw-Type Stuffing Boxes
- Two-Piece Fluid End on DA-850 and D-1000
- Four-Runner Skid, Standard on D-700, DA-850, D-1000

★ All models except D-175 and D-300

MANUFACTURED BY

CONTINENTAL-EMSCO

Serving the Oil and Gas Industries .. Worldwide

SP711

CONTINENTAL EMSCO COMPANY • A Division of The Youngstown Sheet and Tube Company
General Offices: DALLAS, TEXAS • Plants: HOUSTON • GARLAND • LOS ANGELES

Texas plant are the ore plant, rolling mills, and electric weld pipe and finishing mills. These will be shutdown completely except for maintenance and repair work. Other departments may work shorter schedules as conditions warrant.

National Supply Division Offices Move to Larger Headquarters

Offices of the Northwest division of The National Supply Company will be moved to new and enlarged headquarters in the First National Bank Building, Denver.

Robert D. Stottlemyer is division manager. The division directs the company's oil field supply activities in Colorado, Idaho, Montana, North Dakota, South Dakota, Utah, Wyoming and parts of Nebraska and New Mexico.

Honored for 30-Year Service

William L. Butler, president, W. C. Norris, Manufacturer, Tulsa, right, presents watches to four employes who recently completed 30 years service with the company. Those honored were, left to right, Kyle E. Reynolds, John W. Powers, Raymond P. Engles and Raymond E. Gordon. Terry D. Griggs and Mack H. Seay, not shown, received 25-year service pins.

BRITISH H/E MADE

300 P.A. TRACTOR DRILLMASTER

MULTI-PURPOSE · HIGHLY MOBILE

The Hands-England Drillmaster 300 P.A. Rotary Drill is now available mounted on a Fordson Major Tractor and is illustrated on left.

This design provides great maneuverability and is intended primarily to enable the well known H/E Drillmaster 300 P.A. Rotary Drill to be used for Quarry and Open Cast blast or shot holes.

Although the H/E Drillmaster 300 P.A. mounted on a diesel engined tractor, is ideal for Quarry and Open/Cast operations, it is equally applicable to some difficult "off the road" locations, such as may be encountered during seismic exploration particularly in highly cultivated areas.

An air compressor giving 99 C F M can be mounted directly onto the drill subframe and driven from the tractor engine. This compressor gives an up-hole annular velocity of 3,000 ft./min. when using flush jointed drill pipe and holes of the following sizes:

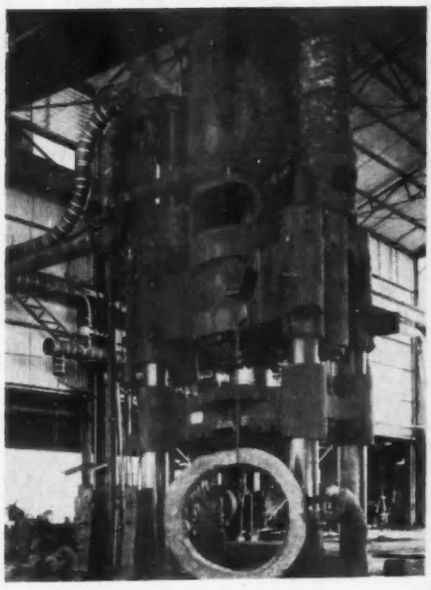
1⅝" o/d. Drill Pipe	2⅞"	dia. hole
1.29/32" " "	3⅛"	" "
2⅜" " "	3⅜"	" "
2⅞" " "	3¾"	" "

Larger holes or holes drilled with mud circulation can of course be drilled, but the equipment for these operations must be mounted on a separate trailer or tractor.

The H/E Tractor Drillmaster will be found to cover the majority of drilling requirements of the Quarry and Open Cast operator, the Geologist, the Mineralogist, and the Geophysicist.

Write for illustrated folders giving full details and specifications of this equipment.

HANDS-ENGLAND OILFIELD EQUIPMENT LTD
MANUFACTURERS OF GEOPHYSICAL SUPPLIES
LETCHWORTH HERTS ENGLAND TEL: 600 CABLES: OIL LETCHWORTH ENGLAND
Exclusive licensees in Western Germany: August Goettker Flachbohrungen, 20a Wathlingen Kreis Celle, West Germany



Huge Forging Press

This giant forging press, owned by The Gulf Forge Company, is the largest steam hydraulic forging press in the Southwest and can exert 4 million pounds of pressure. The press weighs 804,000 pounds, and its foundation is buried in concrete bellbottoms which extend 25 feet into the ground. The tremendous pressure of this press can easily reduce 10-ton steel ingots to billets, shafts or other shapes.

Grant Oil Tool Company Moves Into Los Angeles Expansion

Grant Oil Tool Company is now occupying its new Los Angeles offices and production facilities. The new plant, which covers 20,000 square feet, is another step in Grant's expansion program.

The new offices and plant are located at 2042 East Vernon Ave., Los Angeles.

Southern Marine & Aviation Organizes Overseas Subsidiary

Southern Marine & Aviation Underwriters, Inc., announced the organization of Southern Overseas Underwriters, Inc., a wholly owned subsidiary of Southern Marine. The purpose of the new

EARTHQUAKES MADE-TO-MEASURE WITH CYANAMID EXPLOSIVES

Cyanamid's specialized seismograph explosives make it easier for geophysicists to probe the secrets of the earth's strata on land and offshore. "Made-to-measure" earthquakes have been of invaluable aid in helping to locate the vital crude oil resources so necessary for America's continued prosperity.

Experienced Cyanamid representatives will be glad to advise or help you in any way. There's a Cyanamid magazine... plant... or distributor near you. Just give us a call.

DISTRICT SALES OFFICES: St. Louis, Missouri; New York City, New York; Latrobe, Pennsylvania; Pottsville, Pennsylvania; Scranton, Pennsylvania; Dallas, Texas; Salt Lake City, Utah; Bluefield, West Virginia

THE CYANAMID SEISMOGRAPH LINE:* Hi-Speed • Geogel • Ajax S Pattern Powder — Available with Fast Coupler or E-Z Lok Blasting Agents—Cyamon OS

*Trademark

CYANAMID

AMERICAN CYANAMID COMPANY
Explosives Department
30 Rockefeller Plaza, New York 20, New York

corporation is to handle insurance and reinsurance on offshore and onshore oil drilling and production equipment located in Central and South America. In the beginning, operations of Southern Overseas Underwriters, Inc. will be confined to Venezuela, but the company will eventually operate in most of the Central and South American countries.

The present intent of the new company is to work in conjunction with insurance companies chartered and operating in the Central and South American countries. Southern Overseas Underwriters, Inc., will make immediately available for the benefit of its Latin American correspondents the loss prevention engineering and loss adjustment services and facilities of its parent company, Southern Marine and Aviation Underwriters.

The officers and directors of Southern Marine & Aviation Underwriters, Inc., L. K. Giffin, president, Lee M. Stentz, vice president, Fred Kriedt, vice president and Joseph Rivette, Jr., secretary-treasurer, are also the officers of Southern Overseas Underwriters, Inc.

Bovaird Supply Presents 41 With Time Service Awards

The Bovaird Supply Company climaxed its annual sales meeting at Western Hills Lodge near Tulsa, by presenting awards to 41 employes with 10 to 40 years' service with the company.

Gifts presented by President Davis D. Bovaird included luggage to R. E. Batchelor and F. J. Robbins for 30 years' service; a watch to Ava Turner for 25 years; silver service to Charles Hamm and Brad ord Williams for 20 years' service; and clock radios to G. E. Ferguson, Frances Combs and Lady Barnes for 15 years' service, extra vacation time for 35 and 40 years of service.

Davis D. Bovaird, president of Bovaird Supply, presents awards to F. J. Robbins, manager tubular sales, and Raymond Batchelor, vice president, for their 30 years with the company.

Gifts for 10 years' service were presented to Essie Stephenson, R. F. Ewing, W. F. McIlvain, R. B. Reeves, E. J. Taylor, M. M. Quinn, Gentry Adams, C. W. Dempsey, Jerry Vaughan, Jack Hamilton, M. B. Park, Mary Hohn, Stanley Mead, Earl Henson and Paul Brown.

Ten-year awards will be presented in the field to Henry Webb, Billy Gay, A. A. Fose, B. B. Thompson, W. W. Markley, A. M. Camp and J. Wallace.

Eleven employes have previously received watches as they reached their 25 years of service with the company and became members of the 25-Year Club. They are: R. M. McMahan, J. B. Hubbard, R. H. Baxter, Hettie Strain, Davis Bovaird, Queen Davis, Raymond Batchelor, F. J. Robbins, R. W. Robbins, L. O. Flud and Clara Langstron.

Offshore

OIL INSURANCE

—Loss prevention service included!

YOUR INSURANCE AGENT or broker knows the importance of experienced handling in arranging proper coverage, and he knows how much proper servicing of losses can mean to you. For this reason he will probably recommend placing the insurance on your offshore oil drilling and production equipment with a specialized market such as Southern Marine.

Important too, our Loss Prevention Service (included at no extra cost) is geared to work with you in preventing loss to (1) reduce future insurance costs and (2) prevent equipment down-time. Even with full reimbursement for loss or damage, equipment down-time for repairs knocks out your income. Ask those who use our Loss Prevention Service how well it works.

SOUTHERN
MARINE & AVIATION UNDERWRITERS, INC.
NEW ORLEANS

610 Poydras Street — Telephone TUlane 5266

L. K. GIFFIN, President; LEE M. STENTZ, FRED L. KRIEDT, Vice Presidents

This deep-sea pipe laying barge for Brown & Root is now being completed at the Levingston Shipyard.

Brown & Root, Inc., Launches Pipe Laying Barge at Levingston

A new deep-sea pipe laying barge for Brown & Root, Inc. of Houston, was recently launched at the Levingston Shipbuilding Company in Orange, Texas.

The new barge is 350 feet long, 60 feet wide and 22.6 feet deep. Unusual versatility is incorporated into the design of the Brown & Root vessel, for the barge can be used not only for laying pipe, but also for pile driving, setting offshore structures, laying marine cables and other miscellaneous marine work.

Breaking ground for Continental-Emsco's plant are, left to right: Walter Rolfe, Goleman and Rolfe Architects, Houston; Joe Humans, president, Southwest Construction Co., Houston; S. A. Martin, Continental-Emsco, Houston; F. M. Mayer, president, Continental-Emsco, Dallas; W. T. Powell, Continental-Emsco, Dallas; R. Hortenstine, Jr., Continental-Emsco, Houston; J. D. Mihalick, Continental-Emsco, Houston and The Reverend John F. Stevens, Rector St. Timothy's Episcopal Church, Houston.

Continental-Emsco Is Expanding Houston Manufacturing Plant

Continental-Emsco Company, a division of the Youngstown Sheet and Tube Company, is actively engaged in a general expansion of its Houston Manufacturing plant facilities.

The expansion program will consist of the following major projects:

A new engineering office building of approximately 20,000 square feet floor area, and of masonry construction, located adjacent to and connecting to the existing office building.

Completion of the plant expansion program will virtually double the size of the Houston Manufacturing plant.

Scheduled completion date for the expansion program is Dec. 31, 1958.

The Oil Field Manufacturing division of the Los Angeles plant will be transferred to the new Houston facility.

Two West Coast Plants Consolidated by Dicalite

Great Lakes Carbon Corporation has announced the consolidation of two of its Dicalite diatomite plants on the West Coast. The Walteria, Calif., diatomite plant, which has been in operation since 1930, will be closed and the factory equipment dismantled and moved to the Dicalite plant at Lompoc, Calif. As a result of this move, the productive capacity of the Lompoc Dicalite plant for diatomite filteraids, fillers, insulation and other materials is expected to be increased about 70 percent. Overall production capacity of the Dicalite department will remain the same.

The equipment transferred from the Walteria plant will be installed at Lompoc as a separate unit from existing facilities, forming, in effect, two plants at the one location.

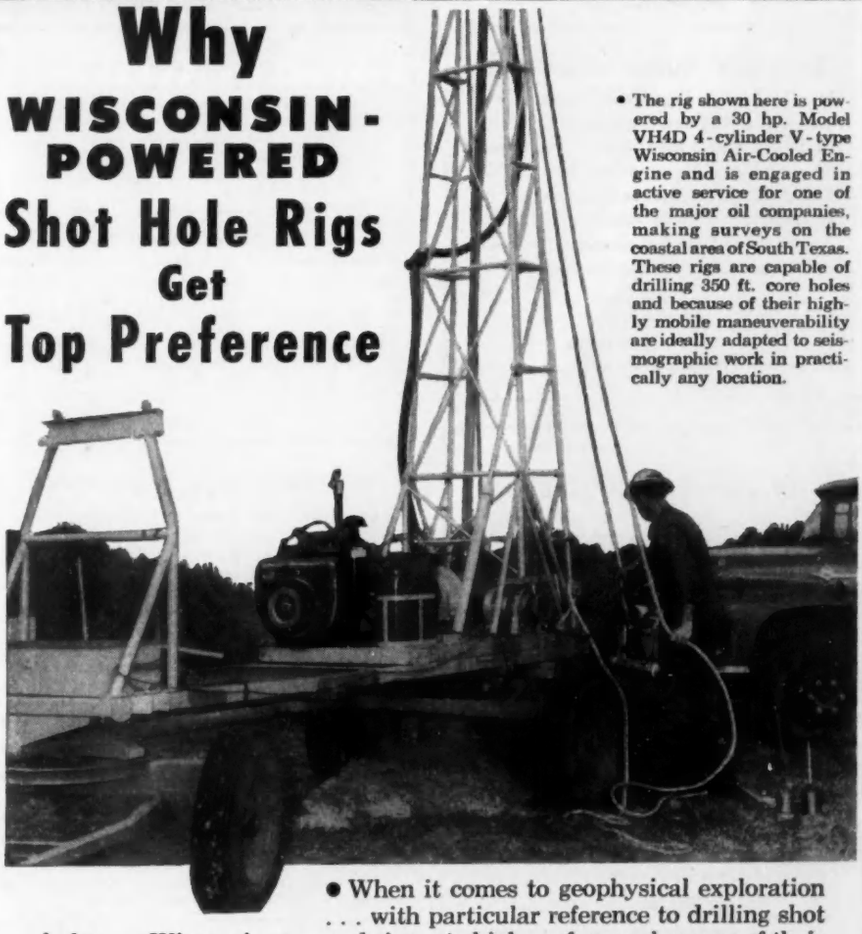
Magnet Cove Barium Corp. Obtains Mud Supply Company

Magnet Cove Barium Corporation, one of the Dresser Industries, has announced the acquisition of Mud Supply Company, Inc., a Magcobar distributor in Louisiana headquartered at Lake Charles. There will be no change in company policy or personnel, and I. W. Hoskins will continue as Mud Supply's president and general manager.

Tube-Kote, Inc., Appoints Lucey As Export Sales Representative

Lucey Export Corporation of New York has been named export sales representative for Tube-Kote, Inc., in Brazil and Argentina. Lucey Export Corporation's representative in Rio de Janeiro is Oscar Bernardes.

Why WISCONSIN-POWERED Shot Hole Rigs Get Top Preference



• The rig shown here is powered by a 30 hp. Model VH4D 4-cylinder V-type Wisconsin Air-Cooled Engine and is engaged in active service for one of the major oil companies, making surveys on the coastal area of South Texas. These rigs are capable of drilling 350 ft. core holes and because of their highly mobile maneuverability are ideally adapted to seismographic work in practically any location.

• When it comes to geophysical exploration . . . with particular reference to drilling shot holes . . . Wisconsin-powered rigs rate high preference because of their heavy-duty dependability, relatively light weight, simplicity of operation and servicing, High Torque Performance characteristics and all-weather AIR-COOLING.

The Wisconsin Engine will keep slugging away in any climate, in any weather, at temperatures ranging from low sub-zero to 140° F. Trouble-free AIR-COOLING makes the difference! And when it comes to serviceability, Stellite exhaust valves and valve-seat inserts, in combination with positive-type valve rotators, increase valve life up to 500% . . . with a comparable reduction in servicing.

If you have a power job within a 3 to 56 hp. range, let a Wisconsin Heavy-Duty Air-Cooled Engine handle it. Write for Engine Bulletin S-223.

WISCONSIN MOTOR Corporation
MILWAUKEE 46, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.
619 SOUTH MAIN STREET • TULSA, OKLAHOMA
3420 McKINNEY AVENUE • HOUSTON, TEXAS
505 SOUTH MAIN STREET • WICHITA, KANSAS
OIL FIELD DISTRIBUTORS FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS

A8-6177

For more data on advertised products, use Readers' Service Cards, last page.

WORLD OIL'S Trading Post CLASSIFIED ADVERTISING

RATES: Regular Classified (undisplayed) **set in this size type: 20 cents per word. Minimum charge $4. Blind box address in our care counts six words. Replies forwarded without charge. Display Classified ads,** set in suitably larger type **with ruled border, $13.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. All classified ads payable in advance.** Send copy and checks to: **Trading Post Classified Section. World Oil,** P. O. Box 2608, Houston, Texas.

HELP WANTED

REFINERY SUPERINTENDENT

Middle East Independent Producer has opening for Refinery Superintendent with 10 to 15 years experience to supervise operation and maintenance new 30,000 BPD plant. Individual selected should be between 35-50 with ability coordinate American and foreign personnel. Resume and details should be addressed:

Box 154-W
WORLD OIL
Gulf Publishing Co.
Houston, Texas

WANTED—ENGINEERS

We are interested in employing Mechanical or Petroleum Engineers, preferably with a practical oil field background, including rotary or workover rig experience. Men in their twenties preferred; should be under age of 35.

BAKER OIL TOOLS, INC.

P. O. Box 3048 Houston 1, Texas

SALES ENGINEER WANTED

Well-established successful firm has opening in an expanding sales department for young man looking for an opportunity in sales work. Must be college graduate, not over 33, in good health and not afraid of work. Oil industry experience desirable. Applicant will be trained at home office before moving into sales work on basis of salary plus commission incentive and traveling expenses. Our own sales personnel know of this advertisement. Your reply will be confidential and should be sufficiently complete to merit contacting you for an interview. Address Box 153-W, WORLD OIL, Houston, Texas.

WANTED: Experienced accountant for aggressive, Denver based, independent oil firm. Must be able to assume office manager position. Excellent salary for top caliber man. Send complete resume to Box 146-W, WORLD OIL, Houston, Texas.

■ Sales Engineer by major tubular manufacturer for southwest. Field experience desired but not required. Salary dependent on background. Car and expenses and other substantial benefits. Box 150-W, WORLD OIL, Houston, Texas.

HELP WANTED

WANTED: Geologist with top qualifications for top paying job with aggressive Denver independent, active in Colorado and Canada. Canadian experience desirable but not necessary. Send references and qualifications to Box 145-W, WORLD OIL, Houston, Texas.

SITUATIONS WANTED

■ Petroleum Engineer: 29, family, four years experience oil and gas production, gas processing and transmission. Obtaining MBA degree in June, available July. Desire Administrative position requiring Engineering knowledge with independent Producer. Box 151-W, WORLD OIL, Houston, Texas.

FOR SALE

MODERN OFFICE BUILDING

containing 9800 square feet, completely air-conditioned, at 2434 Holmes Road, Houston, Texas, with 20.70 acres (surface only) 850 feet highway frontage. Also shop buildings and pipe racks. Private railroad trackage extending entire length of tract. Ample water supply.

GULF OIL CORPORATION, Houston, Texas

Call J. N. Henderson, CA 5-3141, Ext. 460

■ Magnetometer, Vertical temperature compensated ten gammas scale division. Askania, Excellent condition. $900.00. Box 149-W, WORLD OIL, Houston, Texas.

■ 2 used latest model Wheland HP 14000 7-1/4 x 14 power slush pumps, excellent condition—one completely overhauled under factory supervision. Other good used drilling equipment. Industrial Supply Company, 500 8th Street, Wichita Falls, Texas.

BUSINESS OPPORTUNITIES

■ OIL FIELD HAULING—Cen. W. La. Net $32,687. Heart E. Tex-La oil indus. Near lake Caddo. A-1 eqpt-roll stock. Hwy #1 loc. Estab. '49. Gr. poten. Ask $25,000. Write B 9657.

■ OIL COMPANY, W. CEN. TEXAS. 110 whlse. accounts. Hub of South Plains business. ½ acre. Xlnt oppty. Ask $26,500. Write B-10050.

■ COAL COMPANY—NW N. J. 4-1/5 acres, nu office bldg & res. Set up for fuel oil. Xlnt poten. Ask $28,500. Terms. Write B43059.

■ COAL COMPANY, W. PA. Est. '47. Lge. potent. 4½ acres in gd. loc. High gross. Ask $30,000. Write B-42956.

BUSINESS MART OF AMERICA
5723 Melrose Ave.—Los Angeles 38, California

BUSINESS SERVICE

■ Delaware Corporations formed and serviced. Inquire without obligation. American Guaranty & Trust Company, 910 West Street, Wilmington, Delaware.

GM Diesel Picks New Distributor For Northern California Area

The GM Detroit Diesel Engine division has named Williams & Lane, Inc. of Berkeley, as new distributor of General Motors two-cycle diesel engines in the San Francisco Bay and northern California area.

The company is a new corporation formed to handle the Detroit division's line of industrial, marine and truck diesels exclusively.

Heading the new company is James R. Williams, president; N. L. Lane, vice president; and W. M. Glade, treasurer. Heading the Parts and Service departments are Harry Flossi and Jack Jones, respectively.

SSC Buys 3 Logging Units, Bringing Total Number to 11

Expansion of the Continuous Velocity Logging facilities of Seismograph Service Corp., Tulsa, has been announced. SSC has purchased three velocity logging units from Magnolia Petroleum Corporation's Geophysical department, bringing to 11 the total number of units operated domestically by SSC.

The units, operating under Robert S. Finn, vice president for domestic exploration, and CVL Manager Howard R. Breck, will boost the company's CVL activities.

A new CVL station has been opened at Victoria, Texas, with Garland Carlton as manager and J. L. Vantrease as logging engineer. One of the newly-acquired units will be located there, with the other two operating at existing stations.

American Independent Oil Co. Gets Cleaver-Brooks Distillation Plant

Transforming salt waters of the Persian Gulf into 10,000 gallons of pure fresh water daily for drilling and exploration in Kuwait will be the job of a Cleaver-Brooks flash type evaporator recently ordered by the American Independent Oil Company. The flash evaporator, an efficient water-maker, is included as part of the packaged distillation plant, along with two 200 horsepower Cleaver-Brooks CB boilers which will supply steam for heat energy.

Dresser A. G.'s SIE Division Expands European Operations

Dresser A. G., European affiliate of Dresser Industries, Inc., announced the expansion of the firm's Southwestern Industrial Electronics division.

Chris Ring, formerly with SIE of Houston, has been appointed manager of the division. William N. Reese, also formerly with the Houston company, has been placed in charge of technical services.

National Tank and Boiler to Build Modern Metal Fabrication Plant

National Tank and Boiler Company will more than double its size with the completion of a new 30,000 square foot modern metal fabrication plant. The new plant is located in the growing Hazelwood-Berkeley industrial area of North St. Louis County, Missouri.

The new plant will be utilized initially to fulfill a $4 million contract for 18 miles of 6½ foot diameter steel pipe fabricated from ⅜-inch and ½-inch plate. The contract was awarded to National Tank by the Water Department of St. Louis.

BOOKS

SECONDARY RECOVERY RAILROAD COMMISSION HEARING SUMMARIES, 1956, Texas State House Reporter, P. O. Box 2195, Capitol Station, Austin 11, Texas.

The summary contains the data submitted at secondary recovery hearings before the Texas Railroad Commission during 1956 on fields in all 11 commission districts. It supplements a series of eight volumes published earlier this year covering the 11 districts for the period 1933, when the first application was made in Texas for a permit to conduct secondary recovery operations, through 1955.

OIL AND GAS FIELD DEVELOPMENT IN THE UNITED STATES AND CANADA, National Oil Scouts and Landman's Association, Volume 27.

This edition of the NOSLA yearbook reviews oil activity during 1956 and is the largest volume published since the Association was established. It contains 1264 pages.

GEOLOGIC CROSS SECTION OF THE PALEOZOIC ROCKS FROM NORTHWESTERN TO SOUTHEASTERN OHIO, By George G. Shearrow, Ohio Division of Geological Survey, Orton Hall, The Ohio State University, Columbus 10, 50 cents, plus 2 cents tax in Ohio.

Shearrow made the cross section after the study of the cuttings and insoluble residues from 12 wells located in 10 counties extending from Fulton County in northwestern Ohio to Washington County in the southeast. Correlations with Michigan and West Virginia formations are presented.

On the northwestern end of the cross section wells penetrate rocks ranging from Bedford to Lockport in age in the edge of the Michigan Basin. East of the crest of the Findlay arch in Wyandot County, the samples test the formations from Bass Islands to Pre-Cambrian.

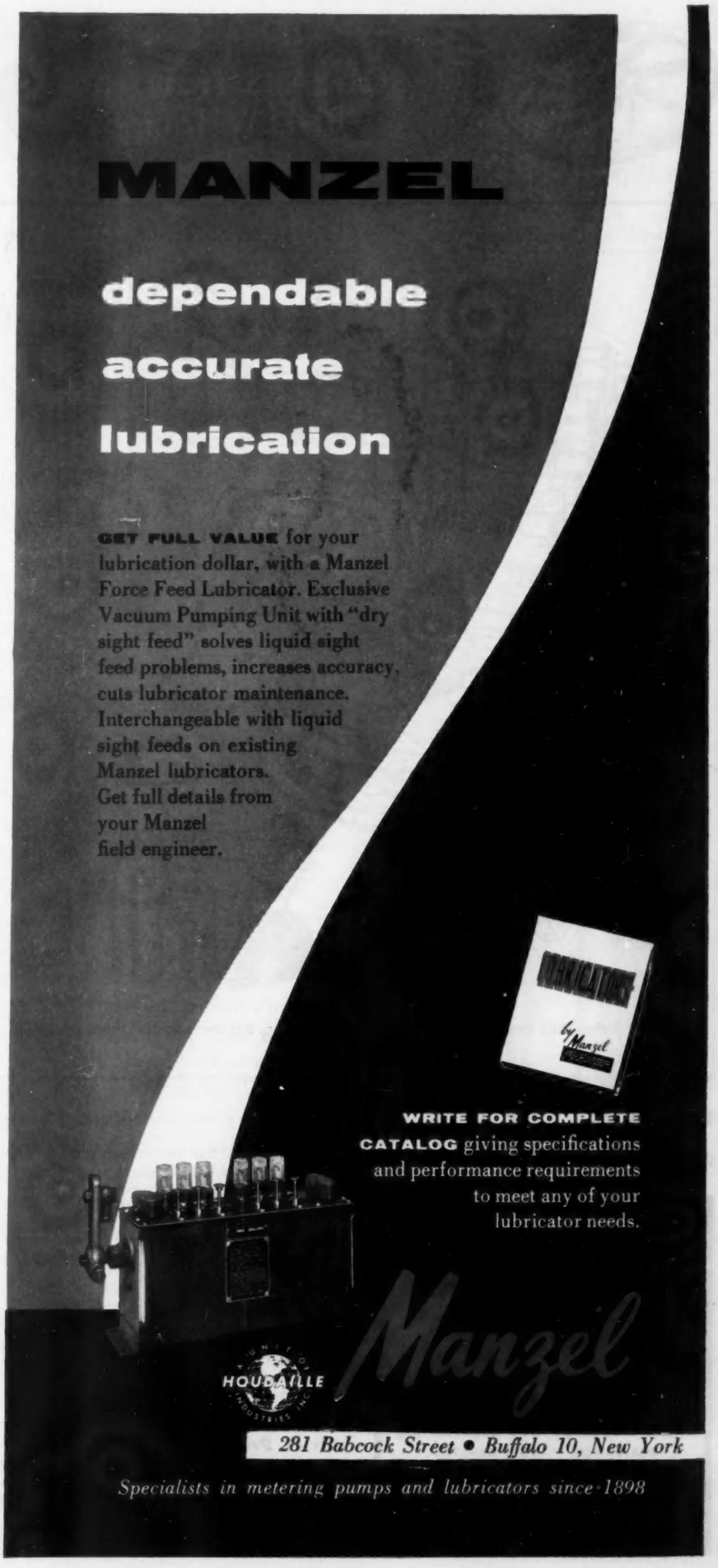
CALIFORNIA OIL FIELDS, Department of Natural Resources, Division of Oil and Gas, San Francisco.

This summary of operations includes special articles dealing with the various phases of oil field operations. These articles present the results of observations of engineers of the Division of Oil and Gas.

Fold-out maps are also included.

OIL & GAS FIELDS OF THE LAREDO AREA, Oil Frontiers Publishing Company, Box 2211, Capitol Station, Austin 11, Texas, $25.

Compiled and edited by Arthur Troutman, the book is a complete history of oil and gas development by Duval, Jim Hogg, Webb and Zapata counties. A map of each county is included, showing the location of fields. Discovery data on each and every oil and/or gas field in the area is also included. The book is liberally illustrated with both contoured geological maps and land plats. Structural data and pay zones are in the report.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GET FULL VALUE for your lubrication dollar, with a Manzel Force Feed Lubricator. Exclusive Vacuum Pumping Unit with "dry sight feed" solves liquid sight feed problems, increases accuracy, cuts lubricator maintenance. Interchangeable with liquid sight feeds on existing Manzel lubricators. Get full details from your Manzel field engineer.
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Specialists in metering pumps and lubricators since 1898

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SQUEAKS from the BULLWHEEL

"At first I thought I had bought my kid a toy marine rig, but now the fool thing produces 800 barrels of oil a day."

Touche

"Yes," said the conceited young bachelor, "I have the greatest admiration for women. But I won't marry one of them—not me!"

"I see," said the sweet young thing, "you not only admire women, but you have a sincere regard for their welfare."

SECONDARY RECOVERY
Since 1922
PETROLEUM ENGINEERS
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FIELD SUPERVISION
Phone 3-2167

100 Percent Correct

"How many successful jumps must a paratrooper make before he graduates?"

"All of them."

In Theory Only

"What did they teach you today in Sunday School, son?"

"I learned to say 'Yes, ma'am' and 'No sir' when answering questions."

"Did you, indeed?"

"Yup."

Strict Protocol

A recruit was on guard duty with specific orders to admit no car unless it bore a special tag. He stopped the tagless car carrying a high-ranking officer. The guard heard the officer order his driver to go right through and calmly the guard spoke up—"I'm new at this, sir; do I shoot you or the driver?"

Medium Or Rare?

A hunter was missing for days—it was feared that something he disagreed with ate him.

Wolf

A guy who always has girls running through his mind—they're afraid to walk!

A Name for Her

They call her Napkin, she's been on so many laps.

A Gilded Fish

A bride, shopping for fish, was trying to impress the fishmonger with her know-how, in spite of the fact that she really was ignorant when it came to piscatorial affairs. She objected to first one and then another of the man's offerings, pretending to find something the matter with each.

Finally, she said haughtily: "I just don't like the looks of any of these."

"Lady," replied the man wearily, "if it's looks you're after, why don't you buy a gold fish?"

Another Goose

Mary had a little lamb
With trimmings and dessert.
Then left the wrong address—
The cheating little flirt.

The Real Reason

Steno Sue: "We met at a picnic. I couldn't help noticing him. Every time I looked at him, he was eating a hot dog and staring at me."

Steno Lue: "Maybe you had the mustard."

Great Expectations

A newlywed filling out his income tax return listed a deduction for his wife. In the section marked, "Exemption claimed for children," he penciled the notation, "Watch this space."

Wear Him Down

A little boy, caught in mischief by his mother, was asked, "How do you expect to get into Heaven?"

The lad thought a minute then said, "Well, I'll just run in and out and in and out, and keep slamming the door until St. Peter says, 'For heaven's sake, Bobby, come in or stay out.'"

Not Again!

"Your hair needs cutting badly," remarked the barber.

"It does not," exclaimed the customer, sitting down in the chair. "It needs cutting nicely. You cut it badly last time."

Friction Results

Engineers are baffled by the fact that often the girls with the most streamlined shapes offer the most resistance.

So There!

Said one angry twin to the other: "If it wasn't for me, you'd have two heads."

The Play's the Thing

"Private Smith! Didn't you realize that you were exposing yourself to an imaginary enemy only 200 yards away?"

"That's OK, Sarge, I was standing behind an imaginary rock 45 feet high."

Over
70
Locations in the United States and Canada

McCullough® REPORTS TO THE OIL INDUSTRY

Service
Anywhere Anytime

New Services • • • New Tools • • • New Methods • • • Outstanding Results

Magna Tector/Chemical Cutter Recover 8905 Feet of Tubing

McCullough Magna-Tector and Chemical Cutter Recover 569′ of Tubing Below Stuck Point Shown by Instruments of Another Make

A free point locator was run in this Wyoming well, by another service company, to find the free point in a stuck string of 2½" tubing. Instrument readings showed the tubing stuck at 8350′.

Operator was not satisfied and called McCullough to verify the lowest free point with the Magna-Tector.

Magna-Tector showed the tubing to be free at 8919′. McCullough's Chemical Tubing Cutter was run and a cut made at 8905′.

Due to the accuracy of the Magna-Tector in locating the lowest free point and the efficiency of the Chemical Cutter in cutting the tubing at the required location, the operator recovered all free tubing in one run of Chemical Cutter.

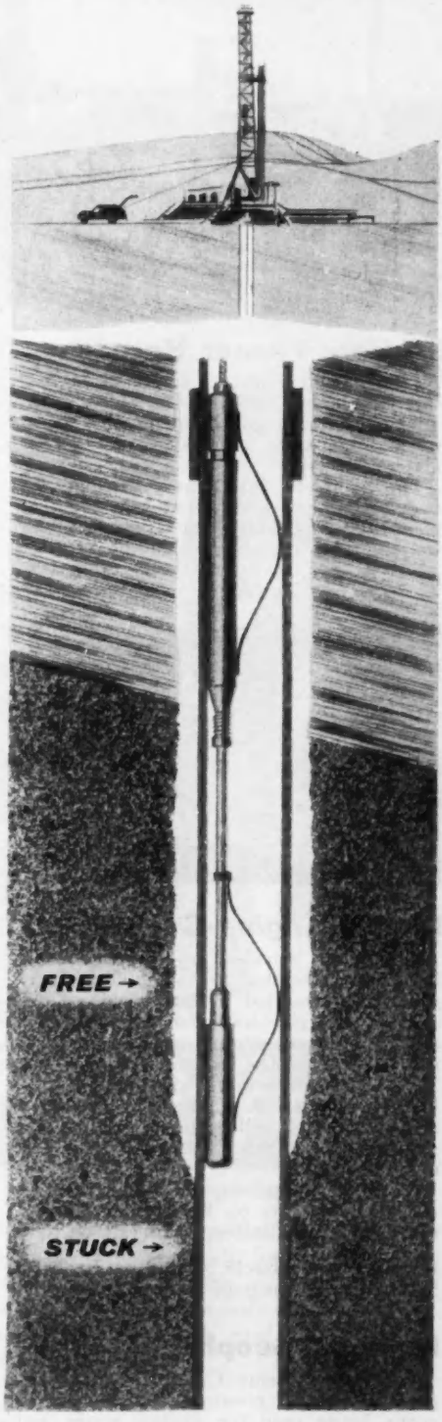
The entire job required only 4½ hours to complete, resulting in substantial savings in rig time and in costs that would have been required to remove the additional tubing by other methods.

The job shown above is certified to be a true field report of service rendered.

ACCURACY OF MAGNA-TECTOR HELPS RECOVER *ALL* FREE PIPE

When pipe is stuck, call for McCullough's Magna-Tector (Free Point Finder). Locates lowest free point, accurately and in a hurry. Paves the way for fastest recovery of all free pipe and speeds up remaining fishing operations. You save money, rig time and recover more pipe. Used in drill pipe, tubing and casing.

Ideal companion tools of the Magna-Tector—McCullough's String Shot Back-Off Tool, the Chemical Tubing Cutter, and Jet Casing Cutter. McCullough Service Engineers will give you full information and recommend the proper tool for your particular job.



McCullough® TOOL COMPANY

Cable Address: MACTOOL

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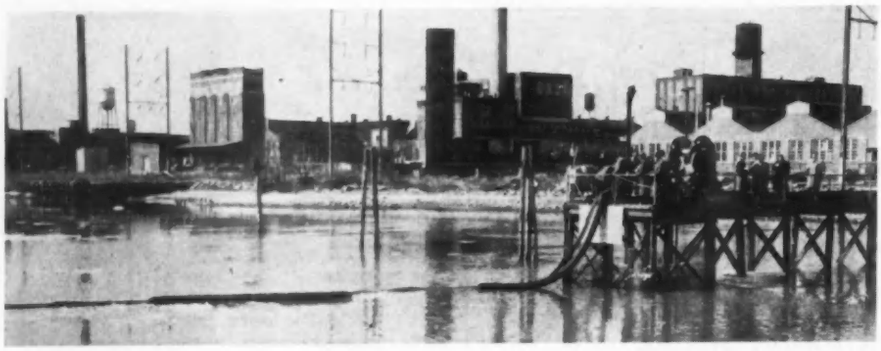
For more data on advertised products, use Readers' Service Cards, last page.

What's New in EQUIPMENT and SERVICES

Drilling - Production - Exploration

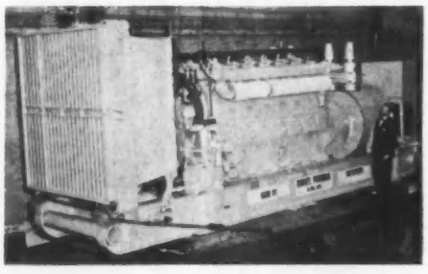


Offshore Floater Hose

The Quaker Rubber Division, H. K. Porter Company, Inc., has introduced an efficient and economical method of loading and unloading tankers offshore in its floater hose unit.

The complete floater hose assembly is made up of three different but complementary components. The component is the 250 foot continuous lengths of discharge hose. Just one length of this continuous hose eliminates the weight and expense of four bulky couplings presently being used on the standard 50 foot lengths of hose. It also results in easier handling due to the fact that it can be reeled in and out.

For more data, circle **No. E1** on Readers' Service Card, last page this issue.



Drilling Engine-Generator

Illustration shows a new unitized drilling engine coupled to two 500 kw DC generators mounted in tandem. It is designed primarily for offshore and other oil industry power applications. The unit is identified as Drilpak and features the 900 hp 8 cylinder YL diesel engine of Davey, Paxman & Company, Ltd. The unit illustrated will supply power for drawworks and three slush pumps on an offshore rig.

(This item supplements Davey, Paxman & Co., Ltd., data on Pages 4269-4276 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E2** on Readers' Service Card, last page this issue.

Pressure Geophone

Marsh & Marine Cable Service Company, Inc.'s MH pressure geophone is currently being used for shallow water and deep water seismograph reflection work in coastal and offshore geophysical exploration. This same geophone is being employed in a vertical array assembly for shooting vertical spreads in difficult-to-record areas on land operations. For this latter application, it is necessary to drill holes of various depths, such as conventional shot-holes or core-holes, and record with a number of these detectors spaced with various intervals on a string of cable referred to as a vertical array cable.

A vertical survey cable is used for obtaining near surface velocity or weathering information and in some areas is also being used to obtain vertical reflections. This cable employs the Type VH pressure detector which is both removable and replaceable, plugging into a rubber molded housing which is molded to the cable.

For more data, circle **No. E3** on Readers' Service Card, last page this issue.

Strong Load Binders

New Lebus all drop forged, heat treated load binders, with strength to break high test chain, are now offered in four sizes for use with chain up to ¾-inch size. To meet the need of every user they are available three ways: with Lebus hooks permanently installed, with clevis hooks or with links to which the user may attach an extension or special fitting.

(This item supplements Crosby-Laughlin Division, American Hoist & Derrick Co., data on Pages 1414-1415 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E4** on Readers' Service Card, last page this issue.

Transport Helicopter

Vertol Aircraft Corporation received a Civil Aeronautics Administration type certificate for its Model 44 transport helicopter. The improvements made in the Model 44 increase cruising speed, contribute to better flying qualities, add to the power available for propulsion, reduce internal and external noise levels and cut down vibration.

The Vertol 44 was certified at a gross weight of 14,350 pounds, compared with 14,000 pounds in the prototype and the normal gross weight of 13,300 of the H-21C, a military version. It is also equipped with steel-spar metal rotor blades which will give longer service life than earlier blades. A series of stabilization devices make the helicopter easier to fly and more comfortable to ride in.

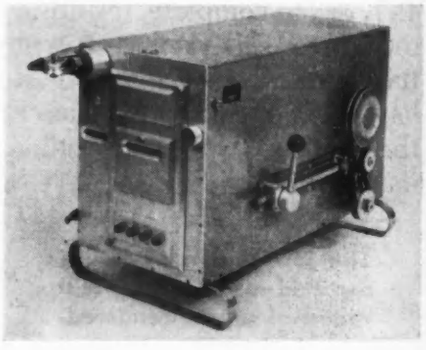
For more data, circle **No. E5** on Readers' Service Card, last page this issue.

Heavy-Duty Truck Trailer

A new self-loading float, especially designed for oil field hauling, has been recently announced by Hands-England Oilfield Equipment, Limited. Designed especially for the handling of heavy oil field equipment and loads up to 75,000 pounds, the float is of the self-loading type with inverted fifth wheel for standard, interchangeable connection and usage with any trucktractor of suitable size.

(This item supplements Hands-England Oilfield Equipment Ltd. data on Pages 2285-2288 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E6** on Readers' Service Card, last page this issue.



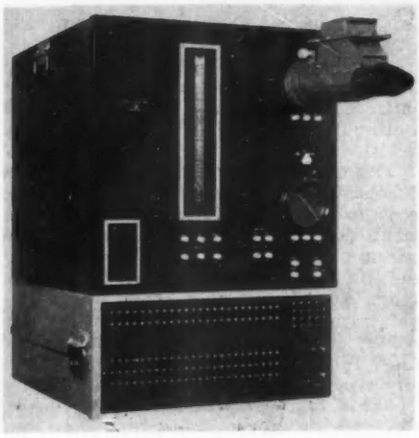
Portable Geo-Logger

Well Reconnaissance, Inc., has recently placed on the market a new version of its portable Geo-Logger, especially designed for low cost electric and gamma ray log-

ging on seismic and shallow core holes.

Completely portable and compact enough to fit into the trunk of most automobiles, the new logger employs the exclusive Well Reconnaissance automatic and instantaneous-developing dry photographic recording process.

For more data, circle **No. E7** on Readers' Service Card, last page this issue.

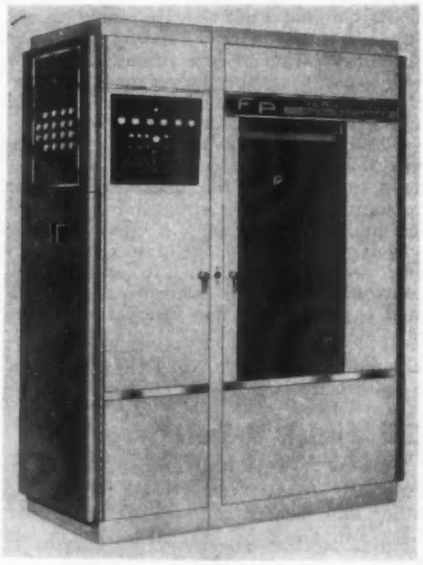


Data Processing System

A new data processing system for quick and easy processing and interpretation of seismic data was introduced by Texas Instruments Incorporated. The VIP (Variable Intensity Plotter) offers central processing office advantages while preserving portability.

Components of the system consist of a visual display unit measuring 31 inches by 31 inches by 32 inches and weighing 65 pounds and a computing unit measuring 31 inches by 13½ inches by 32 inches and weighing 85 pounds. The two units fit together.

For more data, circle **No. E8** on Readers' Service Card, last page this issue.

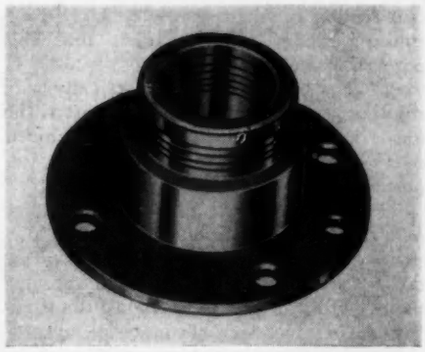


Electronic Artist

An electronic graph "artist" was introduced by Electronic Associates, Inc., of Long Branch, N. J., who reported that this automatic graph maker, the Dataplotter, makes it possible for businesses to make fast, accurate, automatic graph pictures of all the information and data pouring out of the new electronic business computers and to keep a constant graph record of their business operations.

The Dataplotter can make continuous line graphs, bar graphs, multi-colored graphs, broken line graphs or gap graphs made with symbols from a special Symbol Head that supplies up to 12 different symbols. It will plot to a .05 percent accuracy over a 30-inch board. The Dataplotter can plot on paper the size of a postage stamp, up to a sheet 30 inches by 30 inches.

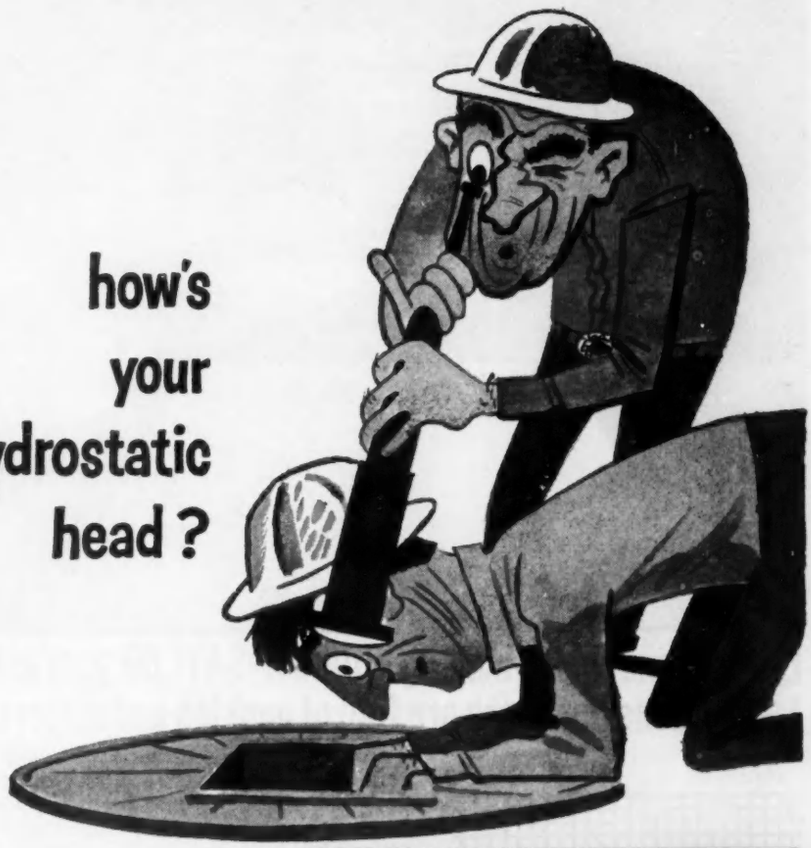
For more data circle **No. E9** on Readers' Service Card, last page this issue.



Rotary Face Seal Line

Skinner Seal Company has announced a line of rotary face seals for use in diffi-

how's your hydrostatic head?



SEE WHAT'S HAPPENING DOWN THE HOLE WITH *Pit-O-Graf*

(Records mud pit level)

From the Pit-O-Graf chart you can calculate effectively any loss in hydrostatic head due to gas or salt water incursion. The continuous mud pit level chart warns of blowouts or threatened blowouts and loss of circulation.

WARREN AUTOMATIC TOOL CO.

Manufacturers of Mud-O-Graf and Rig Runner.

3915 Tharp St. Houston CApitol 4-2511

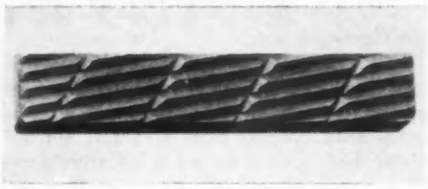
Lake Charles, La. HEmlock 6-2265 | New Iberia, La. EMerson 9-9862 | Harvey, La. FOrest 6-1441

cult sealing problems involving high speed rotating shafts. Skinner states that this particular seal, operating from —320° F. to 1200° F., will handle practically any rotating sealing problem. Because the machined bellows spring seal is a machined part without openings, leakages are impossible.

This seal, with the proper sealing face material, in combination with the bellows spring, remains stationary against the rotating shaft face. Skinner will provide them with facings of carbon, tungsten-carbide or other suitable material, according to the temperature and pressure requirements.

For more data, circle **No. E10** on Readers' Service Card, last page this issue.

DRILLING



Tong Dies

The new Kangaroo tong die available from Kangaroo Tong Dies, Inc., utilizes an unusual tooth-arrangement to provide longer wear and less slippage, according to its maker.

Extra-long teeth afford maximum gripping surface, assuring a strong, positive hold, even on hard-banded joints. Deep grooves and oblique cross-cuts make this die self-cleaning to resist mud and ice.

For more data, circle **No. E11** on Readers' Service Card, last page this issue.

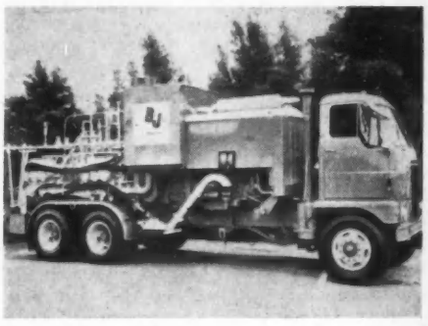
Pump Rod Oiler

The S. R. Bowen pump rod oiler provides a simple, completely effective and trouble-free method of lubricating slush pump rods. It is applicable as original lubricating equipment on new slush pumps and as a replacement for defective or worn-out lubricators on pumps now in the fields.

This rugged self-priming unit furnishes a constant even flow of clean oil on the rods to keep them free of abrasive elements and provides a film of lubricant between moving parts, thereby lengthening the life of the rods. There are no pulleys, gears, belts or extension shafts which may get gummed up or wear out. Neither water, dirt, oil nor sand will damage the unit. It is easily and simply installed on any type or size of reciprocating pump.

(This item supplements S. R. Bowen Co. data on Pages 721-772 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E12** on Readers' Service Card, last page this issue.



Service Truck

A new 670-horsepower pumping truck capable of pumping at pressures up to 15,000 pounds per square inch is announced by BJ Service, Inc., a subsidiary of Borg-Warner Corporation. The new 114-T packs all this power on a unitized cab over-engine truck that offers field mobility.

The 114-T has two triplex pumps and two 335-hp diesel engines—one under the hood, another on the deck. One of the outstanding qualities stressed by BJ Service engineers is its smooth operation—the way it performs even at high speeds without any rocking action. In addition, all controls, valves and instruments are situated to make operation fast, safe and simple.

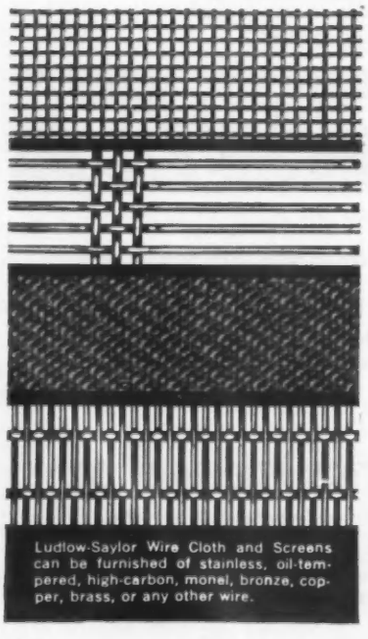
For more data, circle **No. E13** on Readers' Service Card, last page this issue.

Oil Field V-Belt

A new V-belt construction, developed especially for use on oil rig pump and other long center industrial drives, has been announced by Manhattan Rubber division of Raybestos-Manhattan, Inc.

The new Condor LS belt (length stabilized) features a precision proportioned construction reported to eliminate V-belt whip and similar causes of belt turnover and eventual failure common to conven-

Leveling machines built by LUDLOW-SAYLOR guarantee L-S Screens and Cloth are free of buckles and distortion



Ludlow-Saylor Wire Cloth and Screens can be furnished of stainless, oil-tempered, high-carbon, monel, bronze, copper, brass, or any other wire.

To make sure the screens and cloth we ship are flat and accurate, free of bulges and distortion, we put them through a leveling operation on machines we built ourselves. It is an expensive extra that L-S customers appreciate, but which costs them nothing.

This typical attention to quality is why L-S Screens and Cloth are best for every sizing, straining, filtering operation. They have better dimensional stability, resistance to wear, pressure, vibration, heat. Insist on L-S Screens and Cloth—they cost not one cent more.

***Immediate Shipment** of most weaves and sizes*

Write for Condensed Screen Reference Catalog

Ludlow-Saylor WIRE CLOTH CO.

SINCE 1856

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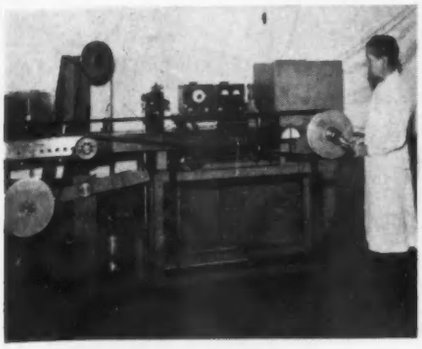
SALES OFFICES: Birmingham, 1727-6th Ave. N.; Chicago, 5708 W. Diversey; Pittsburgh, Union Trust Bldg.; Houston, 1213 Capitol Ave.; Denver, 1530 Carr St. WEST COAST SUBSIDIARY: Los Angeles, Star Wire Screen and Iron Works, Inc., 2515 San Fernando Road.

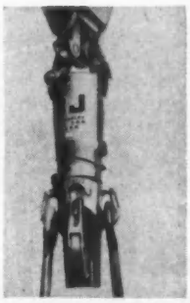


tional V-belt constructions on heavy duty, high powered rig pump and heavy industrial drives. Completely redesigned belt compression area and repositioned strength members give the new belt a great degree of lateral and longitudinal stability with long center rig drives.

New high tensile, super-strength synthetic fabrics have been used in the construction of the belt which is performed before vulcanization to preserve the specially precisioned balance of the newly engineered component parts of the belt's internal structure.

For more data, circle **No. E14** on Readers' Service Card, last page this issue.

Drilling Hook



Byron Jackson Tools, Inc., has received notice that BJ earned an award for their "5500" Hydraplex Hook in the Steel Founders' Society of America's Product Development Contest.

The BJ hook is one of the first of the larger, heavier-duty oil well drilling equipment designed for deep tries. It has a rated capacity of 500 tons and can safely handle the tremendous loads of drill strings five miles or more into the earth. It has many other special BJ features such as the hydraulic snubber, which eliminates the rebound action when "bouncing out" drill pipe stands while coming out of the hole. It also has the patented BJ hook positioner, which can be pre-set to automatically turn the elevator door handles so that they face the derrickman.

(This item supplements Byron Jackson Tools, Inc., a subsidiary of Borg-Warner Corp., data on Pages 973-1108 of the Composite Catalog, 22nd Edition.)

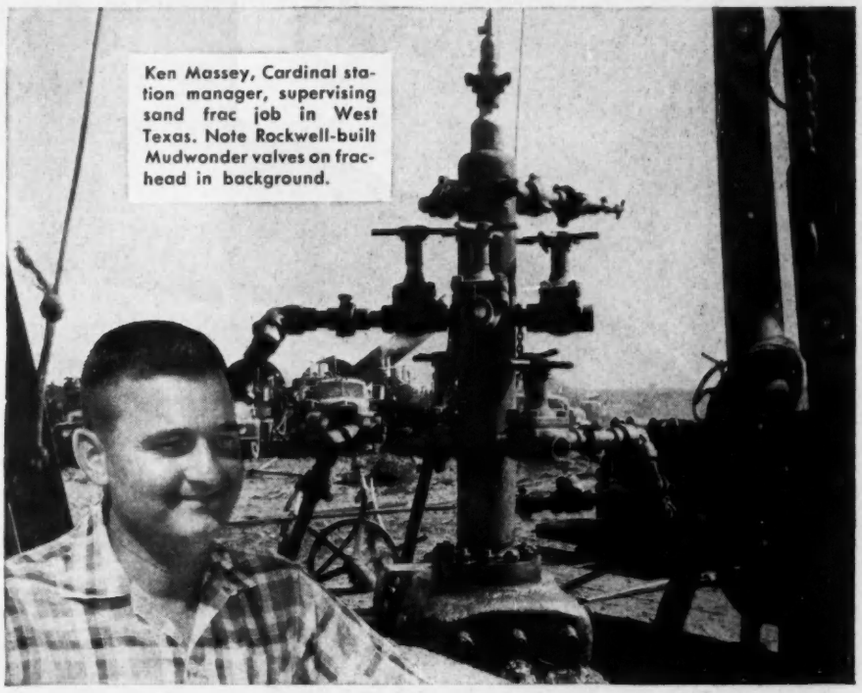
For more data, circle **No. E15** on Readers' Service Card, last page this issue.

Free Dart Game

Something novel in the way of oil tool packaging is announced by Byron Jackson Tools, Inc. Colorful new boxes for their line of PB pipe wipers have been designed to give the products protection and instant recognition. As an added feature, a free dart game is included as well.

The handsome new pipe wiper boxes are made of sturdy corrugated board with the familiar BJ red high-lighted with black and white. On the underside of the

Tips on Valves for Service Companies..



Ken Massey, Cardinal station manager, supervising sand frac job in West Texas. Note Rockwell-built Mudwonder valves on frac-head in background.

We maintain sand frac fluid pressure with Mudwonder Valves!

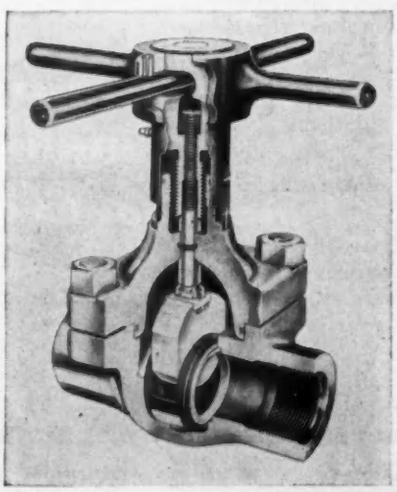
by Kenneth Massey,
Odessa Station Manager
Cardinal Chemical Company

WE fracture oil wells. It's our job to get the maximum number of barrels pumped in the shortest possible time. That's why we use the best, most dependable equipment available—and drive it hard. When we finish pumping the sand frac fluid in under high pressure and close the well-head valves, we've got to be *sure* they don't leak. For two years now, we haven't had to worry. We find that well pressure never bleeds off when our Mudwonder valves are closed. There's no need to bump them shut or use a "cheater" to get drop-tight shut-off.

We now have 40 two-inch Mudwonders and several three-inchers. You might think maintenance would be a headache—but our Mudwonders don't seem to need much in the way of repairs. The only part that wears to any extent is the seat insert, which we can replace in a couple of minutes between jobs.

At the present time, we're using Mudwonders at all of our stations—Odessa and Levelland, Texas, and at Hobbs, New Mexico. We're thoroughly sold. Mudwonder valves are doing a great job for us, both on sand fracing and in acidizing.

Mudwonder cut-away view shows the one-piece seat insert, with Buna-N molded integrally over steel wear rings; chromed gate with "T" slot connection; separated stainless stem and double thread construction.



Mudwonder valves are built in 2", 3" and 4" sizes; with screw or flange ends; for 2000 psi WP (4000 psi test) and 3000 psi WP (6000 psi test) service. See your favorite oil field supply store, or write Edward Valves, Inc., East Chicago, Indiana, subsidiary of Rockwell Manufacturing Company.

ADV.

In 1958 SIE GeoData Processing Centers are revealing the world's complete sub-surface picture

Today, all over the world, MS-12 GeoData Systems are in use. The world's leading petroleum and geophysical organizations are being equipped with **SIE GeoData Systems** as rapidly as possible. These outstanding companies have chosen GeoData equipment in order to utilize properly **all** of the seismic information acquired by modern magnetic recording methods. They have found the GeoData concept offers maximum interpretation flexibility while maintaining the highest standards of accuracy over wide variations in record quality.

GeoData is the essential element required for **full utilization of geophysical data.** The wide acceptance of the MS-12 System demonstrates again how SIE instruments meet every industry requirement in every phase of the modern exploration program.

MS-12 GeoData Equipment with sequential processing reduces first cost — improves accuracy — simplifies operation — provides the complete sub-surface picture.

SIE

SOUTHWESTERN INDUSTRIAL ELECTRONICS COMPANY

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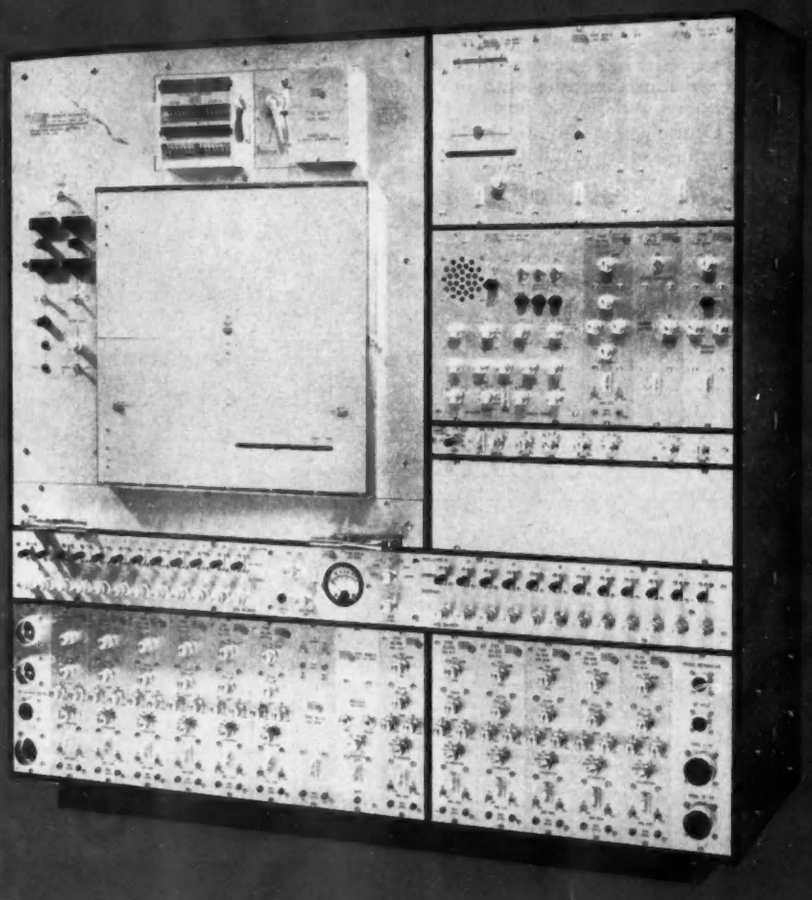

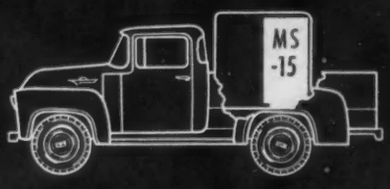

SIE MS-15 MAGNETIC-SEISMIC FIELD RECORDING SYSTEM

...a completely unitized FM installation for use in any field location.

The MS-15 Magnetic-Seismic Field Recording System is a completely new and economical "one-package" unit for magnetic recording and monitoring in the field. All of the high fidelity advantages of the time proven frequency modulation method are obtained at the same cost as AM instruments. The unique "one-package" design of the MS-15 eliminates interconnecting cables, providing dependability characteristics so necessary in a field system.

Twenty-four broad-band, linear phase shift seismic amplifier-FM modulator combination channels are specifically designed for magnetic recording to take advantage of the inherent qualities of the famous standard SIE tapes. Bridged-T hi-line filters are available. The twenty-four seismic data channels and four information channels can be played back through an SIE GA-22 or GA-33 seismic amplifier sequentially and displayed on a monitor drum to verify record quality. Either pen or electro-stylus reproducing methods are available, and no photographic developing processes are required. A dry reproduction of the magnetic recording is available only 2½ minutes after the shot is fired. The system is housed in one sturdy unit and since no darkroom and developing facilities are required, the MS-15 is easily installed in a portable recording cab and transported in a small pickup truck or marsh vehicle.

In every characteristic—FM high-fidelity, lineper stability and ease of maintenance, operating convenience and flexibility, the MS-15 maintains the standards which have made SIE geophysical instrumentation "THE STANDARD OF THE INDUSTRY."

SOUTHWESTERN INDUSTRIAL ELECTRONICS CO.

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SIE

ONE OF THE DRESSER INDUSTRIES

58

box is a specially designed target for the dart game. The game has a special oil-patch flavor with the concentric circles bearing such titles as "gusher," "marginal sand," "dry hole" etc. To add a small element of chance to this otherwise game of skill are some luck areas with such titles as "round trip" and "wildcat," which can pay a premium or demolish a player's score.

Inside the box is a smaller box containing three precision-made English darts. These are sturdy missiles with brass bodies, steel points and plastic fins.

(This item supplements Byron Jackson Tools, Inc., a subsidiary of Borg-Warner Corp., data on Pages 973-1108 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E16** on Readers' Service Card, last page this issue.

Guide Shoe

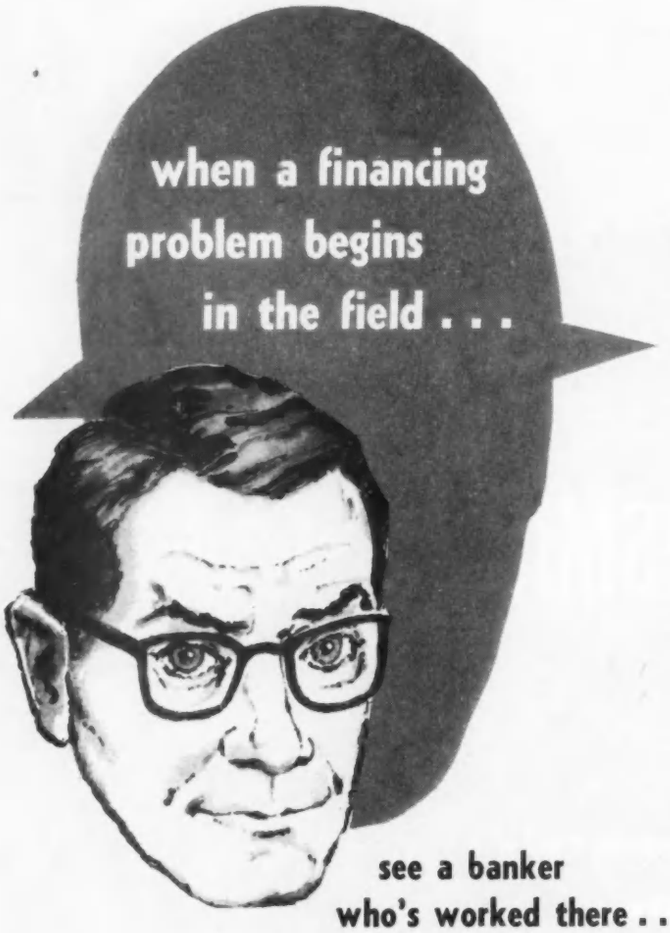
A special 30-inch guide shoe for spudding in offshore locations with big savings in time has been developed by Rector Well Equipment Co. The shoe, butt-welded to a 220-foot string of casing and operated from a crane barge, uses the jetting action of water forced at 400 psi through holes in the aluminum nose to speed up drilling the conductor string hole through the silt that covers the floor of the Gulf of Mexico.

The special Rector guide shoe, believed to be the largest made, has a rib-reinforced aluminum nose that can be drilled out readily when desired depth has been reached.

(This item supplements Rector Well Equipment, Inc., data on Pages 4401-4432 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E17** on Readers' Service Card, last page this issue.

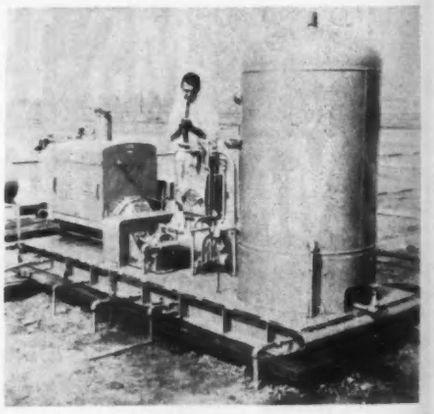
Member Federal Deposit Insurance Corporation



The Petroleum Department at Texas National Bank is headed and staffed by specialists in both production *and* finance.

TEXAS National BANK
OF HOUSTON

PRODUCTION



Single Well Pump

Now in production is a hydraulic pumping installation for single wells, to be known as the Kobe Solo (single oil well operation). It is designed as a complete package surface unit to allow "well by well" equipping of a lease until the final central power plant for multiple well operation can be planned and installed.

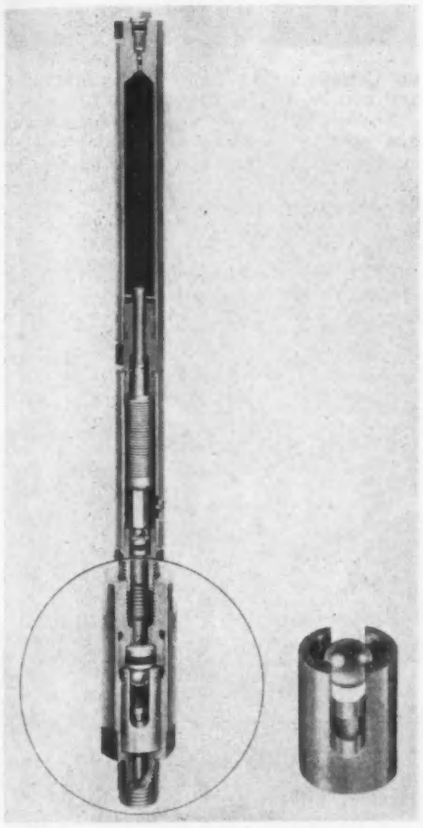
The down-hole free pump system is unchanged and permanent. The single well feature of the Kobe Solo unit allows conventional gaging of well production, and the free pump feature of the system provides the convenience of bottom hole pressure data and the ability to change pump size. The mobility and well testing features of the unit provide an ideal solution to the problem of equipment planning for the uncertain well or lease.

It powers the bottom-hole Kobe free

pump until other wells need equipping and can be put on a central power Kobe pumping system. It eliminates the need for temporary pumping set-ups and later change-overs.

(This item supplements Kobe, Inc., data on Pages 2893-1912 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E18** on Readers' Service Card, last page this issue.



Ball Check Valve

A new and unique magnetic ball check valve, has been announced by Harold Brown Company.

The new magnetic ball check valve is made from nickel alloys which are as non-corrosive as nickel itself. The ball is produced from titanium carbide with a nickel binder, while the cage is of monel metal. Permanent magnets are inset inside the walls of the cage, three on either side. In action, the ball tends to rest at the upper edges of the cage, since this is the area of the strongest magnetic field. The long travel of the ball without a corresponding reduction in return force is one of the novel features of the magnetic cage.

The non-corrosive feature is vital to successful operation of ball check valves in gas lift equipment.

(This item supplements Harold Brown Co. data on Pages 871-873 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E19** on Readers' Service Card, last page this issue.

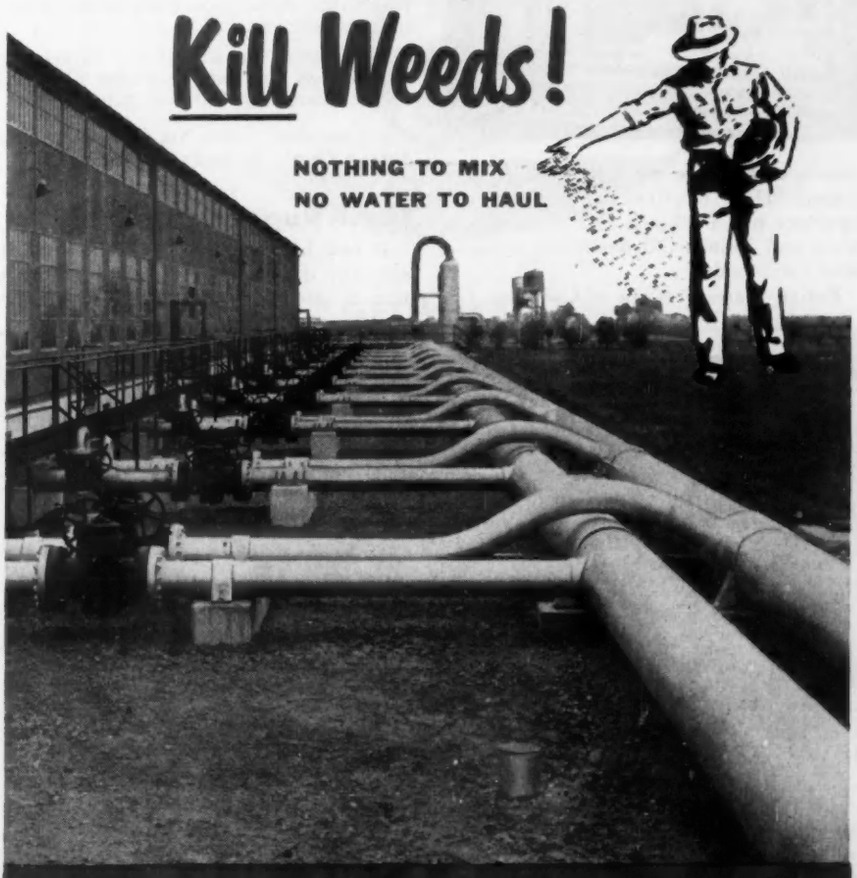
Skid-Mounted Wellhead

Parkersburg Rig & Reel Company has introduced two skid-mounted wellhead field production units. They are "Hyreco" cold separation units.

Each unit is designed to process 20 million cubic feet of gas per day and 2000

Here's the easy way to

Kill Weeds!



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BORASCU® WEED KILLER

.....prevents regrowth—one application may keep area clear of weeds and grasses for 1 or 2 years!

This weed killer gives lasting control of fire-hazardous vegetation... and that's what you need in the Petroleum Industry. Low cost, easy application, safety and convenient packaging are other important features you get with Concentrated BORASCU. Use it anywhere, in any climate, to destroy weeds. Concentrated BORASCU is nonpoisonous, nonflammable, and noncorrosive to ferrous metals... try it!

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United States Borax & Chemical Corporation

PACIFIC COAST BORAX COMPANY DIVISION

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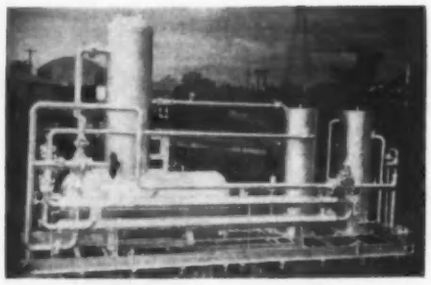


barrels of distillate per day. The T-bone-shaped "HR" (hydrocarbon recovery) separator has a 30-inch OD vertical cold tower and 36-inch OD horizontal accumulator for liquids.

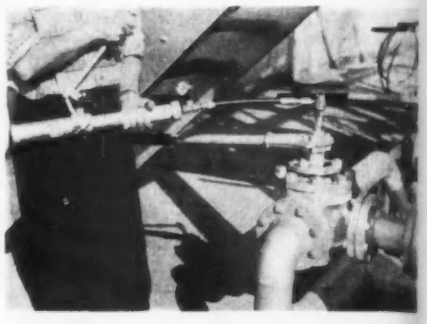
Design pressure of the HR separator is 2000 pounds per square inch. The horizontal accumulator contains an internal pipe coil to heat the cold liquid hydrocarbons condensing from the cold tower. There are two vertical liquid knockouts (4000 psi working pressure) on the unit to provide initial separation of the incoming well-stream.

(This item supplements Parkersburg Rig & Reel Co. data on Pages 4221-4264 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E20** on Readers' Service Card, last page this issue.

Light, Rugged Handgun

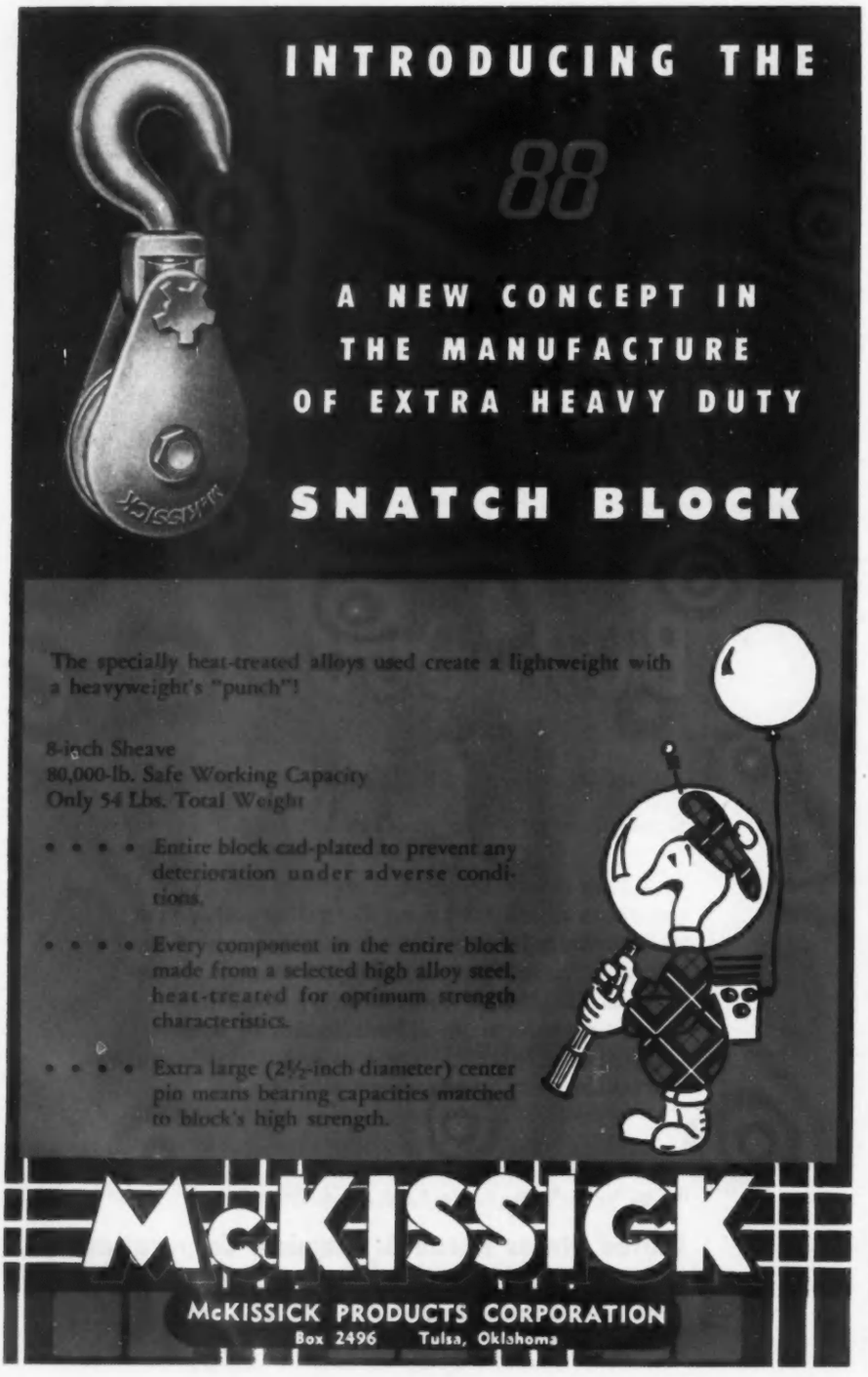
A new high-pressure hydraulic handgun specially designed for plug valve lubrication is offered by Rockwell Manufacturing Company. The "400-C" is self-priming and can be used in any position.



Because of the extra-high pressure this gun exerts, the hose and coupler can be locked to the buttonhead fitting in the valve shank. The pressure may be relieved by a turn of the by-pass valve on the gun—readily permitting separation of the buttonhead coupler and fitting.

(This item supplements Rockwell Manufacturing data on Pages 1606-1609 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E21** on Readers' Service Card, last page this issue.


INTRODUCING THE
88
A NEW CONCEPT IN
THE MANUFACTURE
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SNATCH BLOCK
The specially heat-treated alloys used create a lightweight with a heavyweight's "punch"!
8-inch Sheave
80,000-lb. Safe Working Capacity
Only 54 Lbs. Total Weight
• • • • Entire block cad-plated to prevent any deterioration under adverse conditions.
• • • • Every component in the entire block made from a selected high alloy steel, heat-treated for optimum strength characteristics.
• • • • Extra large (2½-inch diameter) center pin means bearing capacities matched to block's high strength.
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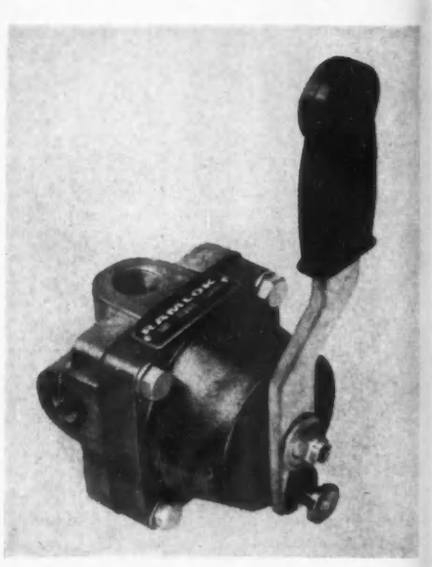
McKISSICK PRODUCTS CORPORATION
Box 2496 Tulsa, Oklahoma



Hydraulic Control Valve

"Ramlok" valves are now in production and offered for sale through all oil field supply stores by Fluid Power Controls, Inc. Some of the most critical components in an oil field preventer hookup are the hydraulic control valves which actually operate the preventer when danger strikes.

If preventer pressure supply fails, a built-in check valve holds pressure in the preventer to keep is closed. This check valve is automatically bypassed when operation of the valve is resumed. Accidental crushing of pipe with blind rams is eliminated by a positive safety lock, saving needless repairs and expense.

For more data, circle **No. E22** on Readers' Service Card, last page this issue.

Gas Analyzer

The availability of a new, industrial thermal conductivity gas analyzer for the continuous monitoring of one constituent in a wide variety of combination gases is announced by Beckman/Process Instruments Division.

The instrument, designed the Model 7C, is designed for use in measuring such gases

Gravimetry Geomagnetic Geoelectric

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"I've ALWAYS preferred KING GA SWIVELS"

King Swivels 32GA and 53GA have been popular for many years. They have proved to be rugged, dependable and durable, and are in use around the world because they are "preferred".

The fact that King Oil Tools is the largest manufacturer of lightweight swivels is supporting evidence of King engineering, service efficiency and complete all-around dependability.

INDUSTRY RECOGNIZES KING GA SWIVELS BY THESE FAMOUS FEATURES:
- ALLOY STEELS assure strength with minimum weight.
- PACKING is V-type, often called chevron type.
- WASHPIPES are seamless alloy tubes, case-hardened and ground.
- GREASE LUBRICATION for the packing.
- MULTIPLE BALL BEARING UNITS provide ample capacity.
- OIL BATH LUBRICATION for the bearings.
- Choice of BAIL OR ELEVATOR SHANK.

FOR FULL INFORMATION ON ALL KING SWIVELS — SEE YOUR NEAREST DISTRIBUTOR — OR WRITE:

KING OIL TOOLS
P. O. BOX 15146 • HOUSTON 20, TEXAS • ORchard 3-3421

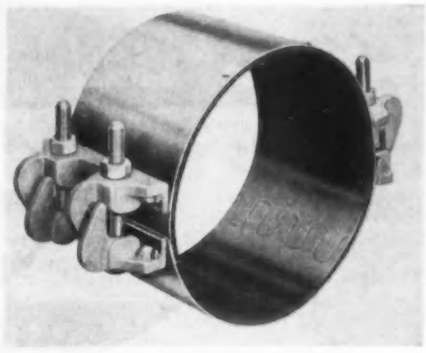
as nitrogen, hydrogen, argon and carbon dioxide. The use of the instrument as a safety device has been proven in the monitoring of hydrogen in carbon dioxide purged systems.

Measuring 18-3/8 by 15 by 11-1/16 inches and weighing approximately 50 pounds, the Model 7C utilizes ultra-sensitive thermal conductivity filaments as detecting elements.

For more data, circle **No. E23** on Readers' Service Card, last page this issue.

Pipe Repair Clamp

Here is a new all-around pipe repair clamp, the Dresser Manufacturing Division "360." Made of stainless steel and Grade A malleable iron, this clamp provides an easier-to-install, efficient method of repairing full breaks or holes in



asbestos-cement and cast iron water lines in oil fields.

The manufacturer cites easy installation—simply remove the bolts from one side of the clamp, spring the clamp around the pipe, insert the bolts and tighten the nuts. An exclusive lug design is featured on the "360" which insures against bolt bending and assures uniform gasket pressure around the full circumference of the clamp.

For more data, circle **No. E24** on Readers' Service Card, last page this issue.

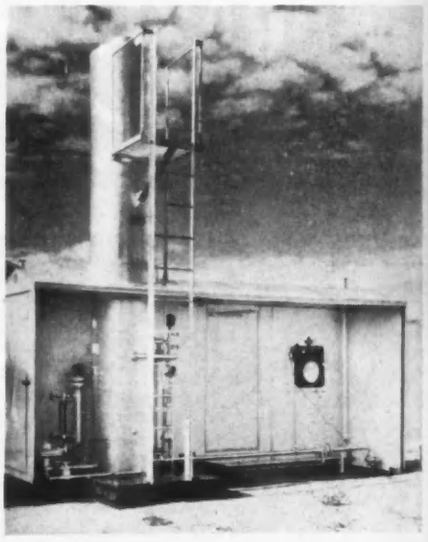
Mobile Unit

Introduction of a new unit capable of doing servicing or workover to 5000 feet, cable tool workover to 4000 feet and rotary drilling to 2500 feet with 3½-inch drill pipe has been announced by Cardwell Manufacturing Company. The new unit has an input rating of 120 hp, air controls and Cardwell Flex-Disc clutches. The basic unit is designed with cross members for trailer or truck mounting.

Cardwell's new unit is known as Model A-150 and A-151. The A-150 model is an engine powered unit, and the A-151 model is driven by the truck engine.

(This item supplements Cardwell Manufacturing Co. data on Pages 1213-1276 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E25** on Readers' Service Card, last page this issue.



Gas Dehydrator

Rolo Manufacturing Company will manufacture and sell the Fish Engineering Corp. calcium chloride gas dehydrator.

Using a series of reflux trays and baffles, the calcium chloride unit uses brine from the dessicant bed to strip water from the gas stream prior to passing through the speciaiiy compounded calcium chloride pellets. The unit combines the advantages of low cost and unattended operation, a major factor in inaccessible locations, especially offshore.

(This item supplements Rolo Manufacturing Co. data on Pages 4564-4565 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E26** on Readers' Service Card, last page this issue.

Sensitive Analyzer

A new technique for well-site analysis of gas samples has been developed by Hycalog, Inc. It has a sensitivity many times greater than conventional gas detectors. The new technique, identified by

TEX-TUBE

SHOT HOLE CASING 16 GAGE - 19 GAGE With The EXCLUSIVE SPEED COUPLER JOINT

Strong, and light-weight Tex-Tube Shot Hole Casing with the exclusive Speed Coupler Joint will solve your shot hole problems! Light enough to carry in—strong enough to drill with! Each length of 16 gage Tex-Tube Shot Hole Casing weighs only 20 pounds. Each length of 19 gage weighs 13 pounds. The exclusive Tex-Tube Speed Coupler Joint makes up fast—without collars. Only two quick turns make a water tight connection strong enough for high pressure jetting. Field tests prove Tex-Tube best.

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Bilderback Dynamite Co.	Lafayette, Louisiana	CEnter 4-6184
	Houma, Louisiana	UPtown 2-0861
Par-Tain Exploration Co.	Bakersfield, California	FAirview 5-3764
Deupree Distributing Co.	Oklahoma City, Oklahoma	JAckson 8-6740
Grove Hardware Co.	Oklahoma City, Oklahoma	JAckson 8-4886
Teton Tool Co.	Mills, Wyoming	CAsper 2-7181
Seismic Service Supply, Ltd.	Calgary, Alberta, Canada	5-5691
Venezuelan Supply, C. A.	Caracas, Venezuela	71-53-21
National Supply Co. Export Division	New York City	CIrcle 6-3232

Tex-Tube, Inc.

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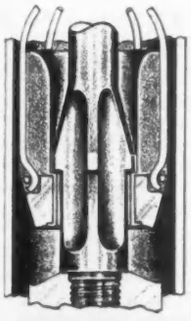
UN 9-3411

Baton Rouge, Louisiana
ELgin 5-1430

Houma, Louisiana
UPtown 2-0569

FIRST REAL SWAB ADVANCEMENT IN YEARS

The development of the Oil States mandrel and swab cups has given the industry one of the *greatest swabs ever to hit the market.* Operators everywhere find the Oil States Swab Cups last longer and pull a bigger load. They say they can really make money with an Oil States Swab.



Cup position when going into hole.

Fig. 1

OIL STATES SWAB CUPS
The free pivoting wire, as shown in Figs. 1 and 2, allows the cup to respond to the lightest loads and, at the same time, lift the heaviest loads — NO BENDING OF WIRES REQUIRED!

Cup position when coming out of hole under load.

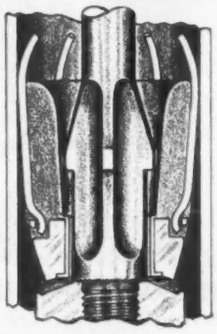


Fig. 2

OPERATORS EVERYWHERE ARE SWITCHING TO OIL STATES SWABS

Oil States

OIL STATES RUBBER CO.
ARLINGTON, TEXAS

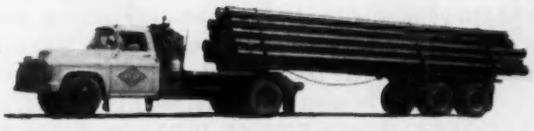
Congrats and $25 to LEE BLACKER, 843 Belmont Ave., Long Beach, California.

"...ready to swab!"

Any swab who's worth his salt . . . knows that Lone Star casing, tubing and line pipe is representative of steel pipe at its API best.

The mammoth Lone Star Steel plant . . . complete and quality-controlled from ore to finished pipe . . . was dedicated from the first as a dependable source of supply for Joe Roughneck, symbolic heart of the oil and gas industry. Every length of Lone Star API pipe is fully normalized.

Neighbor, wherever you are, specify Lone Star and we both get a good deal.



Lone Star STEEL COMPANY

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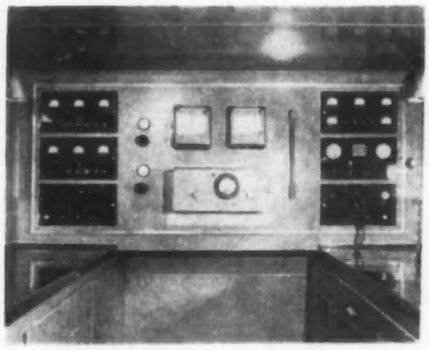


The Gas Chronofrac unit is a two-phase elution system employing a hydrogen-methane monitor and a component analyzer which normally operates in the range of C-1 to C-4 hydrocarbons.

The special type of detector, developed by Hycalog, is able to cut analysis time to less than two minutes.

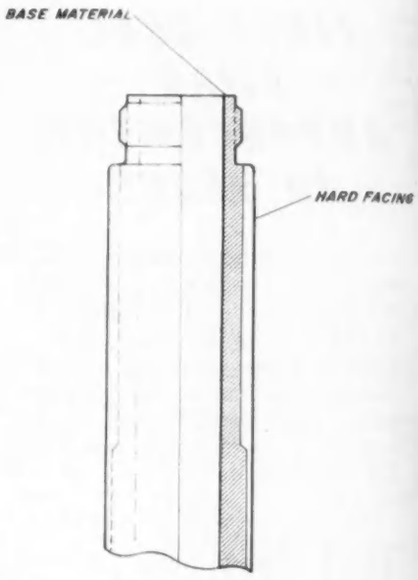
(This item supplements Hycalog, Inc., data on Pages 2565-2572 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E27** on Readers' Service Card, last page this issue.

the trade name Gas Chronofrac, is achieved by chronological fractionation of samples which are taken at measured intervals directly from the flow line.

Subsurface Pump Plungers

A new plunger surface which is almost as hard as a diamond, resists abrasion and will not gall, is the newest development in

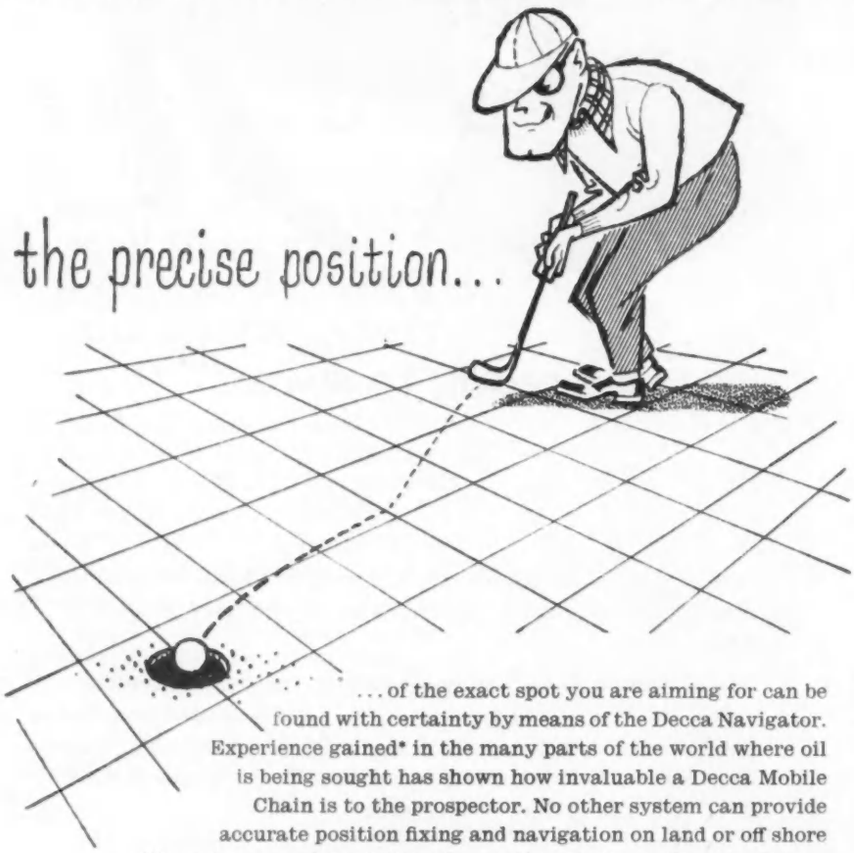


subsurface pump plungers by the Axelson Maunfacturing Company, division of U. S. Industries, Inc. This new Axite plunger has been designed for use in wells with extremely abrasive and corrosive conditions.

The new plunger is hard-faced with a nickel-chromium-boron material that is sprayed while in a molten state onto a mild steel tube. The hard-facing material is then fused at 1900° to 2000°F. to form a molecular bond with the base metal.

(This item supplements Axelson Manufacturing Co., division of U. S. Industries, Inc., data on Pages 371-374 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E28** on Readers' Service Card, last page this issue.

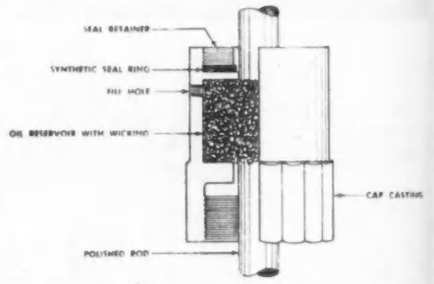


...of the exact spot you are aiming for can be found with certainty by means of the Decca Navigator. Experience gained* in the many parts of the world where oil is being sought has shown how invaluable a Decca Mobile Chain is to the prospector. No other system can provide accurate position fixing and navigation on land or off shore with such ease and flexibility of operation in all weather conditions. With Decca the area can be squared off and worked over with precision—no portion being omitted and none gone over twice—thus enabling a greater area to be covered in a given time. The position of salt domes or other features meriting further examination can be pin-pointed with absolute certainty, and returned to unerringly at any time. The consequent savings in time, manpower and fuel, are considerable. A single Decca Mobile Chain with its wide-area coverage can be used with equal facility by ship, aircraft or truck.

**Decca Chains are in current operation in every type of climate and terrain from Newfoundland to New Guinea.*

THE DECCA NAVIGATOR | **Mobile Chains for Survey and Exploration**

THE DECCA NAVIGATOR COMPANY LIMITED, LONDON, ENGLAND



Lubricator Stuffing Box

Vernon Tool Co., Ltd., announces the addition of a lubricator type stuffing box to their line. Designed for wells that occasionally pump dry or need additional lubrication, this stuffing box is of the same design as the Vernon "Standard" and "Pack-Off" fluid sealed stuffing boxes and is available in either type.

One of the outstanding features of this new lubricator type stuffing box is its simple construction. The cap incorporates a chamber which is packed with absorbent wicking. Upon installation this chamber is filled with oil which may be readily replenished, through the convenient fill connection, as needed. The oil saturated wicking keeps the polished rod lubricated at all times. A wiper ring, built into the top of the cap, keeps the lubrication in and the dirt out.

For more data, circle **No. E29** on Readers' Service Card, last page this issue.

CUT STUCK SAND LINES INSIDE TUBING

KINLEY SAND LINE CUTTER

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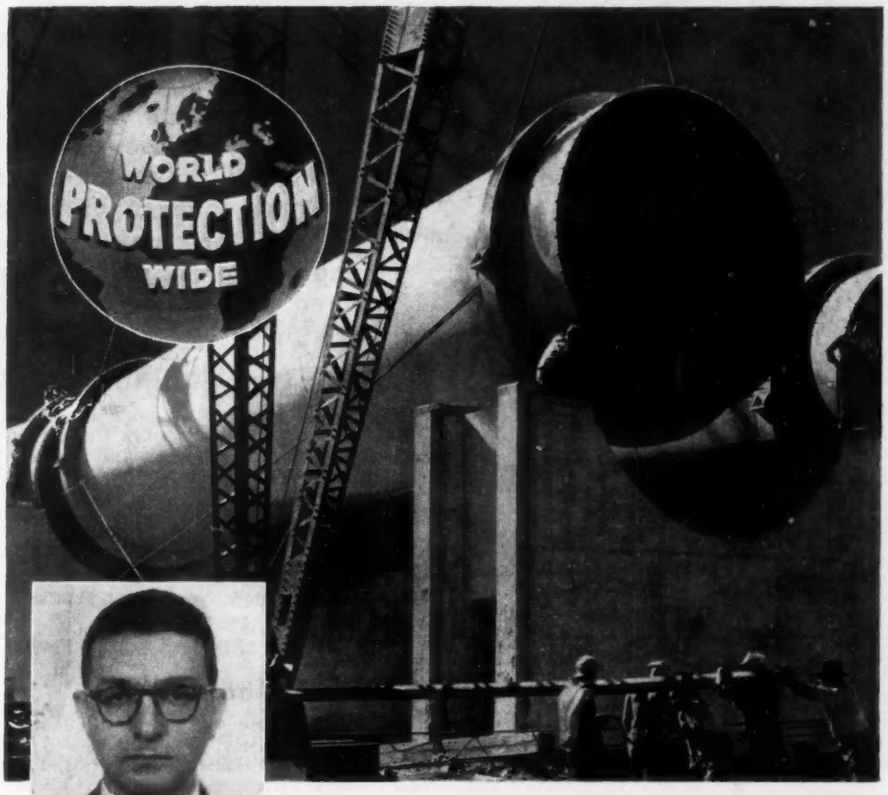

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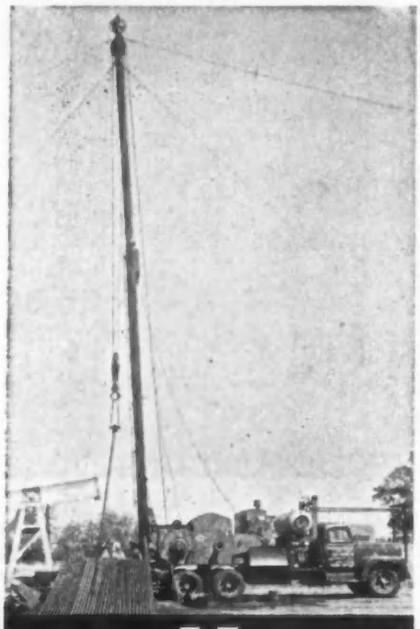

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New Literature

For more data on New Equipment or copies of Catalogs and Literature reviewed in this issue, use the Readers' Service postcards just inside the back cover and facing the Advertisers Index. Simply circle code numbers of items desired—sign and mail card. Requests are transmitted to the manufacturer as soon as received by us for mailing of desired information directly to you.

Pumping Unit Bulletin

A new eight-page, two-color brochure which illustrates and describes the 6-foot and 10-foot Hydrax pumping unit is available through the Axelson Manufacturing Company, division of U. S. Industries, Inc. Specifications for each unit are included, as well as photographs and specifications for optional components.

To get a copy, circle **No. E30** on Readers' Service Card, last page this issue.

Mud Tank Booklet

A new brochure entitled "Mud Tanks for the Oil Industry" has been issued by Niagara Screens (Great Britain) Ltd. This new literature presents comprehensive data on a complete system of handling and storing drilling muds including water tanks, mud storage and settling tanks, ditchers, staging, stairways and walkways. The entire system is designed for a minimum of assembly time in the field and is as readily disassembled for ease of handling and transportation in small sections.

To get a copy, circle **No. E31** on Readers' Service Card, last page this issue.

Flange Booklet

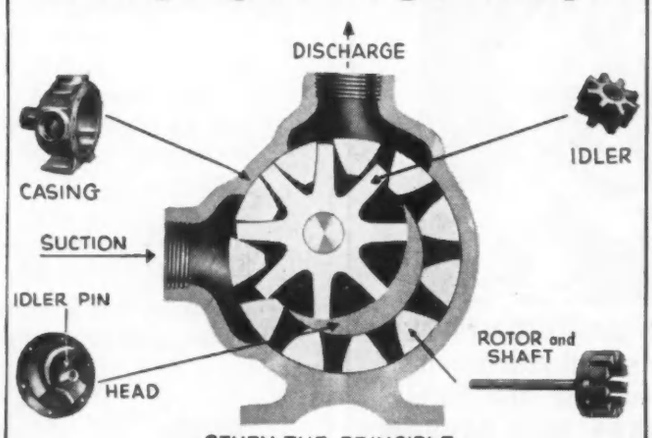
The Oil Center Tool Company has published a 15-page flange dimension reference book, which is based on tentative API Standard 6 B, fifth edition.

To get a copy, circle **No. E32** on Readers' Service Card, last page this issue.

Tank Fabrication Holder

An illustrated bulletin is available from Modern Welding Company giving illustrations and data on their custom-fabricating facilities for the petroleum industry in their plants located at Owensboro, Ky.; Houston; Burlington, Iowa; Orlando, Fla.,

Viking Operating Principle



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and Newark, Ohio. The bulletin gives complete details with reference to facilities and equipment at each location.

To get a copy, circle **No. E33** on Readers' Service Card, last page this issue.

Floodlight Brochure

The Pyle-National Co. has announced the availability of an 18-page bulletin on their new line of mercury vapor floodlights of the heavy duty type. This two-color bulletin contains the latest information on the operating characteristics and operating economies as well as the color characteristics of all the currently available mercury vapor lamps.

To get a copy, circle **No. E34** on Readers' Service Card, last page this issue.

Coatings Treatise

Just off the press is the new industry-wide 36-page protective coatings manual released by the Rust-Oleum Corp. The comprehensive treatise features actual color chips of 102 different coating items and includes complete sections devoted to methods of surface preparation, use of primers and finish coatings and the availability of special custom coatings where required.

To get a copy, circle **No. E35** on Readers' Service Card, last page this issue.

Cyclone Manual

The use of cyclones as a tool to lower the costs of drilling operations is a rather recent development. A new cyclone brochure, 1157, contains data and illustrations of the Heyl & Patterson, Inc., cyclones used by drilling operators.

To get a copy, circle **No. E36** on Readers' Service Card, last page this issue.

Triplex Pump Brochure

A 12-page illustrated bulletin on Kobe triplex pumps has been issued by the manufacturer. Applications include operation of hydraulic test equipment, molding presses, lubricating systems, oilwell pumping and others. Complete description of the pumps and their ratings are continued in the bulletin.

To get a copy, circle **No. E37** on Readers' Service Card, last page this issue.

Retarded Acid Booklet

Dowell Incorporated's folder describes how the retarded acid action is delayed to allow penetration before spending itself. Field results and benefits of retarded acid are shown.

To get a copy, circle **No. E38** on Readers' Service Card, last page this issue.

Wire Rope Folder

A new informative bulletin on "Storage and Lubrication of Wire Rope" has been announced by Leschen Wire Rope Division, H. K. Porter Company, Inc. The proper procedures to follow when either new or used wire rope is to be stored are described in detail, as are the various steps to take when the rope is put back into service.

To get a copy, circle **No. E39** on Readers' Service Card, last page this issue.

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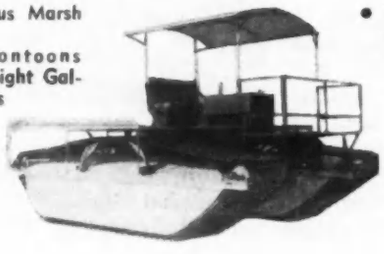

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